CHAPTER 4. ENGINEERING AND OPERATIONAL ISSUES

Engineering and operational issues include the mechanics of obtaining data, analyzing the data, and deciding on a plan of action to solve a particular solid waste handling problem. This chapter addresses the following issues:

- solid waste generation
- technologies for
  - handling and storage of waste
  - collection of wastes
  - transfer and transport of waste
  - landfill design and operation
  - processing techniques and equipment
- resource recovery and recycling
- wastes requiring special handling
- hazardous wastes that may enter normally nonhazardous waste streams.

4.1 GENERATION OF SOLID WASTES

4.1.1 The Resource Conservation and Recovery Act defines solid wastes as:

> "Any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations and from community activities, but does not include solid or dissolved material in domestic sewage, or solid or dissolved materials in irrigation return flows or industrial discharges which are point-sources subject to permits under Section 402 of the Federal Water Pollution Control Act, as amended (86 Stat. 880), or source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954, as amended (68 Stat. 923)."

4.1.2 The types and quantities of solid wastes generated will vary geographically and seasonally. Military installations often have unique activities that generate wastes not found in ordinary municipal wastes. Furthermore, populations at military installations do not follow a normal growth pattern because the growth is controlled by mission requirements. Consequently, determining accurate annual waste generation rates would require a survey at the installation in question.

4.1.3 A knowledge of the quantities and characteristics of solid wastes to be disposed of is important since these factors affect:

1. method and frequency of pickup

2. viability of transfer stations

3. method of disposal to be selected (e.g., incineration, landfilling, etc.)

4. size and/or throughput capacity of the disposal facility required

5. environmental impacts at the disposal location (e.g., types of potential air or water pollutants)

6. viability of Resource Recovery and Recycling Programs (RRRP)

7. potential for waste reduction/minimization.

4.1.4 Solid waste types and quantities generated for a military installation can best be determined by means of a field survey. If resources are unavailable to conduct such a survey, estimates can be made based on existing solid waste generation data for other similar installations.

4.1.5 Solid Waste Types. The types of solid waste that can be expected to be generate at various naval installation sources are presented in Table 4-lA. Although the information is dated, it illustrates the variability in waste composition that can be expected depending on the primary function of an installation. Solid waste composition and quantities that can be expected from various sources are presented in Tables 4-lB and 4-1C.

4.1.5.1 Figure 4-lA compares one Navy survey with a State of Washington survey. The difference in composition is significant. Figure 4-lB breaks down the Washington data by classification of generator as either (1) residential, (2) manufacturing, or (3) commercial/institutional. Again, significant differences are apparent.

4.1.5.2 The figures presented are not meant to be used as design figures for any particular installation. The important point of the information is that both composition and quantity of solid waste will vary significantly depending on the location and the function of the military installation. From an historical standpoint two trends were noticed: (1) total generation rates increased over time and (2) the composition is moving toward more plastics in all streams.

4.1.6 Waste Quantities. Table 4-18 shows reported average per capita solid waste generation rates for military installations as a whole. The table also compares military versus civilian generation rates.

4.1.6.1 The variability of the data in Tables 4-lB and 1C infers that accurate numbers can be determined only by conducting several surveys at the site in question. A quick method would be to check delivery records at the final disposal site. More accurate methods are discussed in Appendix F.

4.1.6.2 For military installations in general, waste generators can be conveniently categorized into 11 groups.

TABLE 4-1A
Average Composition of Solid Waste from Various Navy Installation Sources(1)

Solid Waste Component	Transmission Building/ Laundry Facilities	Exchanges & Commissaries	Ordnance Manufacture and Assembly	Offices, Training Rooms, Dispensaries, and Quarters	Food Service (Cafeteria, Mess, Galley, Canteen, Club)	Shops, Berthing Piers, and Wharves	Storehouses & Warehouses	Ways-Drydocks, Marine Railway, Motor Pool
Paper	84	84	74	72	67	66	64	47
Garbage	<1	<1	<1	<1	5	<1	<1	<1
Metal	3	2	<1	5	5	7	3	8
Textiles	<1	<1	<1	<1	<1	5	<1	4
Plastic	7	9	4	12	14	<1	11	7
Leather	NO	NO	<1	NO	NO	<1	NO	NO
Rubber	<1	NO	<1	<1	NO	<1	NO	2
Vegetation	3	<1	<1	3	<1	<1	<1	NO
Inerts	2	<1	<1	<1	<1	1	1	2
Wood	NO	4	6	2	3	5	15	29
Glass, Ceramics	NO	<1	NO	<1	4	<1	<1	<1
Miscellaneous(2)	NO	<1	11	2	<1	5	2	<1
Total	100	100	100	100	100	100	100	100

(1) Visually determined; values are percent by volume.
(2) Miscellaneous included fluorescent bulbs, fibrous barrels, and carpet trimmings.
(NO - None observed)

TABLE 4-1B
Average Daily Waste Generation Rates from Military and Municipal Sources

	Year	Total Waste Generation, lbs per capita/day	Ref
Military			
Air Force Survey	1971	3.94	1
NCEL Survey	1972	5.81	1
Navy Solid Waste Management Manual	1978	3.3	1
Navy, Guam	1984	5.33	2
Army, Ft. Lewis	1988	3.67	3
Municipal			
EPA National avg.	1975	3.2	4
Charlotte, NC	1977	6.7	4
Omaha, NE	1978	3.3	4
Phoenix, AZ	1978	6.3	4
San Diego Co., CA	1980	5.8	4
King Co., (Seattle, WA)	1982	5.5	4
EPA National avg.	1986	3.6	5
EPA National avg.	1987	3.6	6
Washington State	1987	6.43	7
Puget Sound (WA)	1987	6.48	7
Delaware State	1988	3.29	8

References

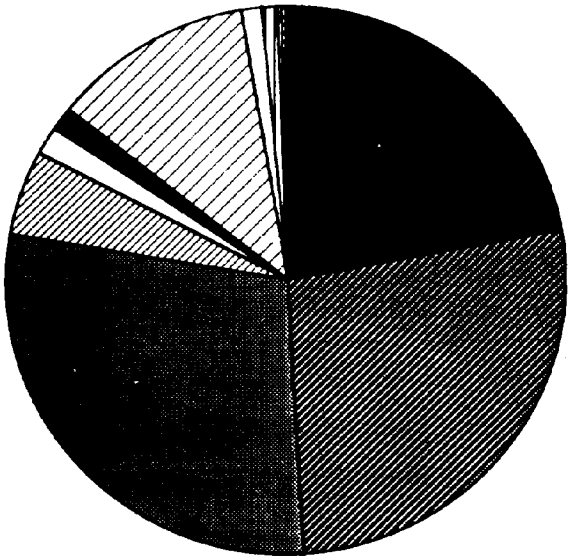
1 SCS Engineers (1984)
2 Roberts (1984)
3 Dave Hanke (Ft. Lewis) Personal Communication (1989)
4 Robinson (1986)
5 Wallgren (1987)
6 Thayer (1989)
7 Matrix Management Group (1988)
8 Vasuki and Canzano (1988)

TABLE 4-1C
Typical Physical Compositions of Some Solid Waste Streams
(All in % by Weight)

	1975 USA Typical City	1971-1975 Davis, CA	1987 Wash. State Residential	Wash. State Commercial/ Institutional	1987 Wash. State Manufacturing	1987 Wash State Total Wastes	1988 Delaware Total Wastes	1984 Navy Charleston	1981 Navy Jacksonville	1987 Tucson, Arizona
Food Wastes	15	9.5	10.9	11.7	2.6	8.8	8.3	22.0	13.5	1.7
Paper	40	43.1	25.7	25.1	23	20.8	20	26.9	47.9	11.1
Cardboard	4	6.5	4.8	16.7	11.6	7.6	25	28.6		18.6
Plastics	3	1.8	8	9.4	12.3	7.4	9	4.9	11.1	7.3
Textiles	2	0.2	3.1	3.5	1.5	3.6		1.8		
Rubber	0.5	0.8	0.8	4.2	1.2	1.7	1.3	1.4		
Leather	0.5	0.7	0.2	0	0.2	0.1			3	
Garden Trim.	12	14.3	22.3	2.9	0.8	18	17.3			17.1
Wood	2	3.5	1.2	7.4	11.6	7.1		11.6	0.8	4.1
Glass	8	7.5	7.2	4.5	3.1	5.2	0.8	1.2	9.4	7.9
Tin Cans	6	5.2	2.5	0.9	0.2	1.5				
Nonferrous Metals	1	1.5	2	4.7	1.2	3.5	1.5	0.6		5.3
Ferrous Metals	2	4.3	0.6	7.2	3.7	3.5	6	0.9	6	
Dirt, Ashes, Brick	4	1.1	7.6	3.4	27.3	9.8	10.8	0.3	0.5	8
Disposable Diapers			3.2	0		1.5				3.6
Reference	1	1	2	2	2	2	3	4	5	6

1 Tchobanoglous, Theisen, and Eliassen (1977)
2 Matrix Management Group (1988)
3 Vasuki and Canzano (1988)
4 Bond, Bingham, and Roberts (1987)
5 Zimmerle (1984)
6 Time (1988)

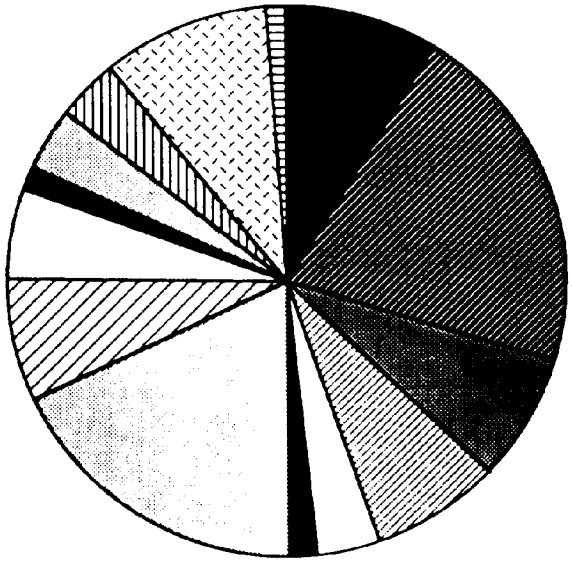
Navy Survey 1984



- Food Wastes
- Paper
- Cardboard
- Plastics
- Textiles
- Rubber
- Leather #
- Garden Trim. #
- Wood
- Glass
- Tin Cans #
- Nonferrous metals #
- Ferrous Metals
- Dirt, Ashes, Brick
- Disposable Diapers #

*Includes garden trimmings
Segments not shown
(unknown or <1%)

Total Wastes
State of Washington 1987



- Food Wastes
- Paper
- Cardboard
- Plastics
- Textiles
- Rubber
- Leather
- Garden Trim.
- Wood
- Glass
- Tin Cans
- Nonferrous metals
- Ferrous Metals
- Dirt, Ashes, Brick
- Disposable Diapers

FIGURE 4-1A
Comparison of Naval Data with State of Washington Data
on Solid Waste Composition

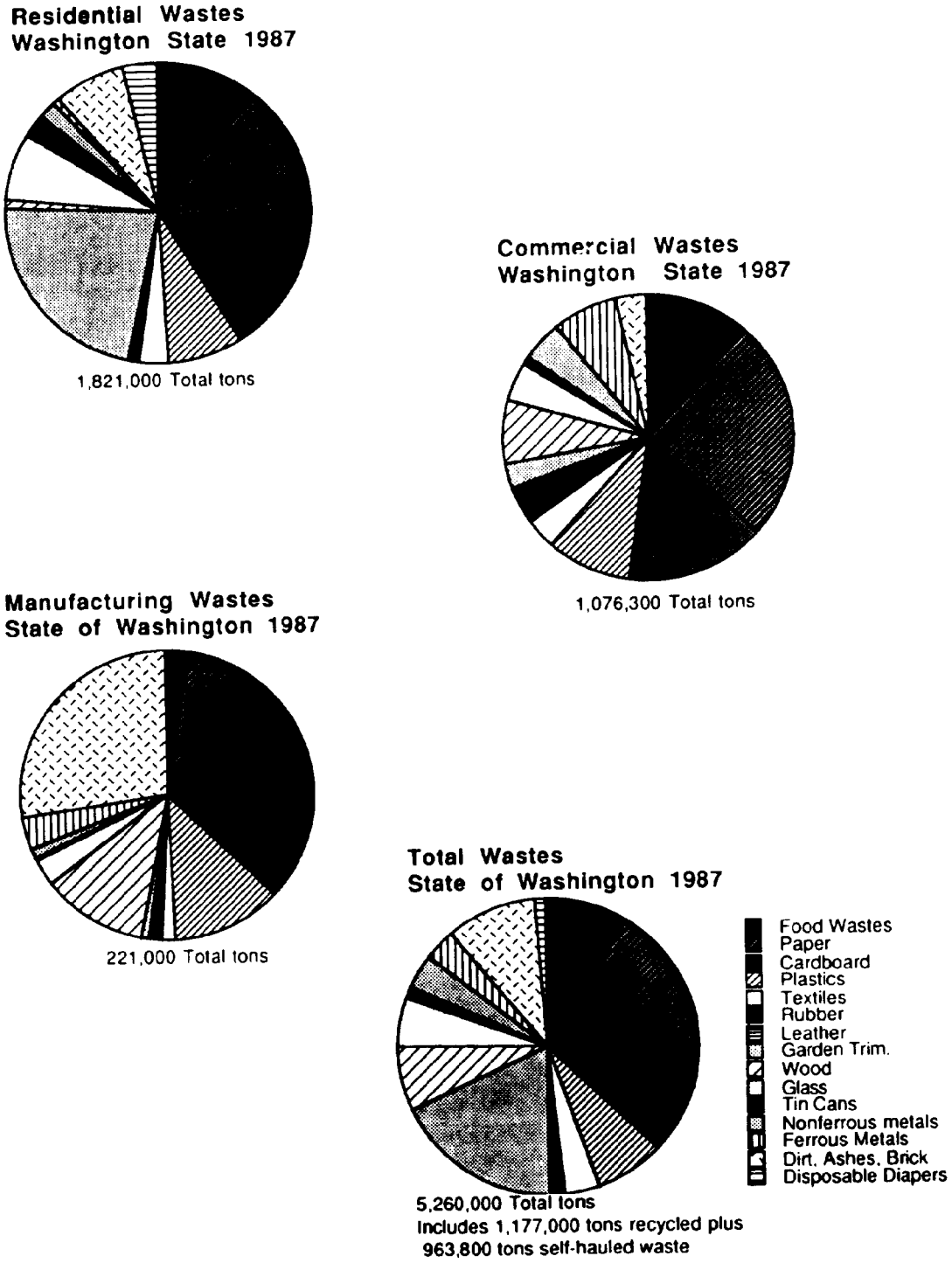


FIGURE 4-1B
Breakdown of State of Washington Data by Category of Generator

1. Residential

   Most residential waste is garbage (food wastes). Next follows paper. then glass, metal, and miscellaneous.

2. Commissaries and Exchanges

   The bulk of the wastes at commissaries and exchanges is clean, high-quality corrugated containers and is excellent material for resale or recycling.

3. Clubs and Messing

   Wastes from clubs and mess halls consist of paper, plastic wrap, cans, bottles, and food preparation trimmings exclusive of bones and fat. Wet garbage is generally disposed of in the installation sanitary sewer system through garbage grinders, while grease, bones, and fat are collected separately and sold.

4. Administrative Offices and Classrooms

   Solid wastes from offices and classrooms consist mainly of paper.

5. Industrial Wastes

   These wastes are generated during overhaul of ships, aircraft, and other vehicles. The wastes are highly variable in quantity and nature. Much of the material is metal and can be treated as recyclable scrap.

6. Construction/Landscaping Wastes

   Lumber, broken concrete, and other building materials are frequently taken to special landfill areas reserved for that type of waste. The “Reserved” area can be adjacent to a regular landfill. The separation results because construction debris often requires different controls and different covers.

7. Motor Pool Wastes

   This category includes automotive, vehicular, and aviation ground-support equipment repair and maintenance activities. The solid wastes generated from these facilities consist primarily of paper and cardboard, along with some quantities of nonreusable wooden crating and packaging materials. Oils and greases generated in these facilities are handled separately, while metals and broken parts are generally segregated from the solid waste stream and disposed of as scrap. Used tires and batteries are also common waste materials.

8. Medical Wastes

   The principal wastes from hospitals and dispensaries include garbage, paper, and trash; surgical, laboratory, and autopsy wastes; outdated

medicine, and noncombustibles such as cans and bottles. Some of these wastes present physical, toxicological, or pathological hazards. Appropriate guidelines for handling these materials are provided in Section 4.4.

9. Military Activity Wastes

Wastes generated during maneuvers include wastes similar to mess facilities plus other wastes such as spent ammunition. Ammunition shells are frequently recycled and reused. Other wastes created on maneuvers are seldom collected.

10. Foreign Garbage

Ships coming into port will have stored aboard the trash generated while the ship was at sea.

Most of the waste is unusable garbage followed by paper, metal, glass, and other. Aircraft and ships returning from foreign ports must have all solid waste off-loaded and incinerated or sterilized prior to disposal.

11. Litter

Roadway barrow pits, beaches, and recreation areas are frequent repositories for litter. Most is metal cans or loose paper. Laws do exist against littering but strict enforcement is not yet practical.

Wastes from all these sources have some recyclable components. Economics presently dictates which materials are recycled.

4.2 TYPES OF TECHNOLOGIES

4.2.1 This section discusses various options for the handling of solid wastes. Topics start from solid waste storage at generation sites and end with ultimate disposal. Recycling issues are presented in detail.

4.2.2 Several methods of waste reduction and disposal are available to military installations. Each provides varying degrees of productivity to the overall refuse collection and disposal process; and their relative merits should be assessed based on local conditions and local, state, and federal policies with respect to solid waste management. The method or combination of methods chosen must prevent nuisance and health hazards by controlling certain agents and conditions, rodents, odors, air pollution, surface water and groundwater pollution, and spread of pathogens and hazardous gases. Selecting the appropriate disposal method should be based on least cost where such studies are conclusive while in accordance with local, state, and federal requirements.

4.2.3 Handling and Storage at Generation Site

4.2.3.1 Storage requirements for solid wastes are spelled out in the Federal Regulation 40 CFR 243. Excerpts follow:

(a) All solid wastes (or materials which have been separated for the purpose of recycling) shall be stored in such a manner that they do not constitute a fire, health, or safety hazard or provide food or harborage for vectors, and shall be contained or bundled so as not to result in spillage. All solid waste containing food wastes shall be securely stored in covered or closed containers which are nonabsorbent, leakproof, durable, easily cleanable (if reusable), and designed for safe handling. Containers shall be of an adequate size and in sufficient numbers to contain all food wastes, rubbish, and ashes that a residence or other establishment generates in the period of time between collections. Containers shall be maintained in a clean condition so that they do not constitute a nuisance, and to retard the harborage, feeding, and breeding of vectors. When serviced, storage containers shall be emptied completely of all solid waste.

(b) Storage of bulky wastes shall include, but is not limited to, removing all doors from large household appliances and covering the item(s) to reduce the problems of an attractive nuisance, and the accumulation of solid waste and water in and around the bulky items.

(c) Reusable waste containers which are emptied manually shall not exceed 75 pounds (34.05 kg) when filled, and shall be capable of being serviced without the collector coming into physical contact with the solid waste.

4.2.3.2 Data on types and sizes of containers used in various applications are given in Tables 4-2-3A and B (Tchobanoglous, Theisen, and Eliassen 1977). Table 4-2-3B provides information so the proper container can be selected for a particular location. Figure 4-2-3A shows several medium capacity solid waste containers.

4.2.3.3 The requirement for waste containers will reflect the characteristics of the source including the rate of waste generation, density of population, and ease of access to both the generating installation and collection system. Proper selection of containers will increase productivity and should provide reasonable benefits to both the discarding unit and to the collection installations.

4.2.3.4 *Location of Containers.* Traditionally, containers at military installations have been located in one of two places: curb or alley, or central collection locations. The use of other locations must be supported by an economic or environmental analysis. Central location collection provides greater productivity in the collection process; however, greater costs for equipment are inherent. Aesthetics is an important consideration in selecting a site location for any container(s).

4.2.3.5 *Receptacle Stands.* Suitable stands for refuse receptacles at pickup stations are essential for efficient and economical collection operations. Discarding units segregate refuse and police the pickup station.

TABLE 4-2-3A
Data on the Types and Sizes of Containers Used
for the Onsite Storage of Solid Wastes

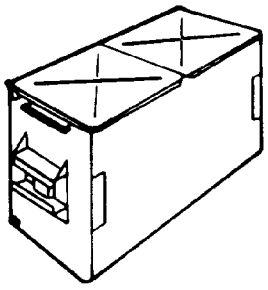
Type	Capacity Unit	Capacity Range	Capacity Typical	Dimensions(1) Unit	Dimensions(1) Typical
Small:					
Container, plastic or galvanized metal or wheeled	gal	20-80	30	in.	20D x 26H (30 gal)
Barrel, plastic, aluminum, or fiber	gal	20-65	30	in.	20D x 26H (30 gal)
Disposable paper bags					
Standard	gal	20-55	30	in.	15W x 12d x 43H (30 gal)
Leak resistant	gal	20-55	30	in.	as above
Leakproof	gal	20-55	30	in.	as above
Disposable plastic bag				in.	18W x 15d x 65H (10 ft^3)
Medium:					
Container	yd^3	1-10	4	in.	72W x 42d x 65H (4 yd^3)
Large:					
Container					
Open top, roll off (also called debris boxes)	yd^3	12-50	--(2)	ft	8W x 6H x 20L (35 yd^3)
Used with stationary compactor	yd^3	20-40	--(2)	ft	8W x 6H x 18L (30 yd^3)
Equipped with self-contained compaction mechanism	yd^3	20-40	--(2)	ft	8W x 8H x 22L (30 yd^3)
Container, trailer-mounted					
Open top	yd^3	20-50	--(2)	ft	8W x 12H x 20L (35 yd^3)
Enclosed, equipped with self-contained compaction mechanism	yd^3	20-40	--(2)	ft	8W x 12H x 241 (35 yd^3)

(1) D = diameter, H = height, W = width, d = depth
(2) Size varies with waste characteristics and local site conditions.

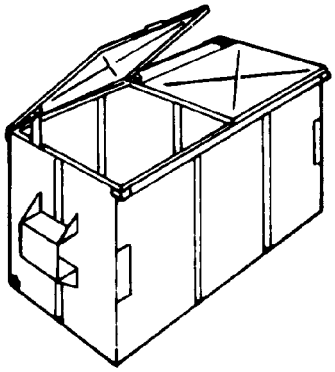
Note: gal x 0.003785 = m^3
in. x 2.54 = cm
yd^3 x 0.7646 = m^3
ft x 0.3048 = m

TABLE 4-2-3B
Typical Applications and Limitations of Containers
Used for the Onsite Storage of Solid Wastes

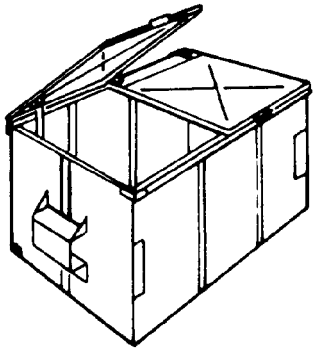
Container	Typical Applications	Limitations
Small:		
Container, plastic or metal or wheeled	Very low volume sources, such as individual residences, walkways in recreation areas, and small isolated commercial establishments; residential areas with setout collection service; wheeled containers are efficient for family housing.	Containers are damaged over time and degraded in appearance and capacity; containers add extra weight that must be lifted during collection operations; containers are not large enough to hold bulky wastes.
Disposable paper bags	Individual residences with packout collection service, can be used alone or as a liner inside a household container; low- and medium-rise residential areas	Bag storage is more costly; if bags are set out on streets or curbside, dogs or other animals tear them and spread their contents; paper bags themselves add to the waste load.
Disposable plastic	Individual residences with setout collection service; can be used alone or as a liner inside household container. Bags are useful in holding wet garbage inside household containers as well as in commercial containers (residential areas; commercial areas; and industrial areas)	Bag storage is more costly; bags tear easily, causing litter and unsightly conditions; bags become brittle in very cold weather, causing breakage; plastic lightness and durability causes later disposal problems.
Medium:		
Container	Medium-volume waste sources that might also have bulky wastes; location shall be selected for direct—collection access (barracks; offices; light industrial areas)	Snow inside the containers forms ice and lowers capacity while increasing weight; containers are difficult to get truck to after heavy snows.
Large:		
Container, open top or lightweight plastic top	High—volume office areas; bulky wastes in industrial areas; location of open top containers shall be within a covered area but with direct-collection truck access	Initial cost is high; snow inside containers lowers capacity. Lightweight plastic not as durable as metal lids.



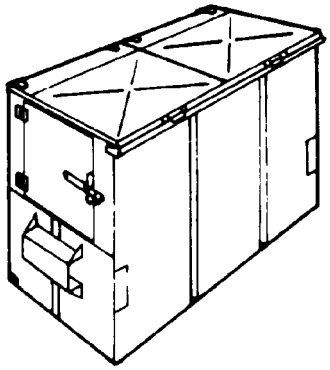
(2 Cubic Yards)



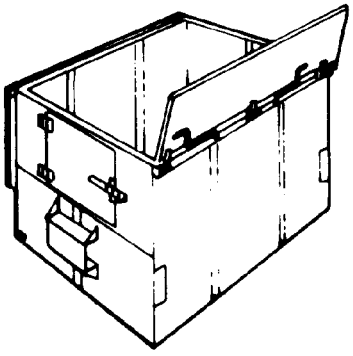
(3 Cubic Yards)



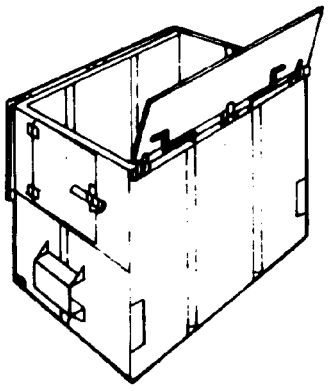
Top Loading
(4 Cubic Yards)



Top and End Loading
(4 Cubic Yards)



Low Top and End Loading
(6 Cubic Yards)



High Top and End Loading
(6 Cubic Yards)

FIGURE 4-2-3A
Medium-Capacity Refuse Containers

Adequate receptacle stands are an aid to good housekeeping. Scheduled spraying for control of insects and rodent-control measures must be established as required by prevailing weather conditions. The following guidelines apply to receptacle stands.

- Locate receptacle stands at established pickup stations only.

- Stands for garbage cans are constructed in conjunction with a can-washing facility at mess halls, service clubs, and exchanges. Because of the low-loading height of most compactor trucks, do not place these stands on porches or loading docks.

- Because of the height of multiple containers, they are more easily loaded when placed adjacent to a loading dock or platform and loaded through their top doors. Whenever possible, locate the receptacle stand for this kind of container in such a position.

- Build stands large enough to accommodate enough receptacles to meet installation requirements for segregation of materials.

- Concrete stands are easily cleaned and seldom require maintenance. Wood stands are not satisfactory at mess halls or other locations where food is dispensed. Existing wooden stands will be replaced with concrete stands whenever replacement or major repairs are required. On paved areas, construction of separate stands is not normally required. Do not enclose receptacle stands. Screened stands are difficult to keep clean and also create a fly-breeding environment. In some instances, a shelter over the can stand may be desirable to protect the cans and contents from becoming wet during rainy weather. Stands shall be at least 30 cm (12 in.) above grade. Stands or pads shall accommodate the wheel-bearing load of loading vehicles.

4.2.3.6 **Washing Facilities**

4.2.3.7 *Can Washing.* Wash all cans as often as necessary for sanitation. Garbage cans do not require sterilizing, but grease and food particles serve as a source of food for insects and rodents and must be removed to prevent a health hazard. Central can washing has generally proven to be an uneconomical operation both in manpower and trucks required to haul cans to and from the messing facility and the can-washing plant. Individual can-washing facilities are authorized for construction for mess halls, restaurants, service clubs, and exchanges. Can washing facility drain lines are connected to a sanitary sewer via a grit/grease trap.

4.2.3.8 Can-washing facilities at mess halls shall be conveniently located, in accordance with the following criteria: a concrete washing pad not less than 6 ft by 6 ft in size, surrounded by a low, raised curb to prevent overflow of wash water, and piped to the central drain having a grease trap and connected to the sanitary sewer. Hot water (not to exceed 140^{0}F) may be piped to the washing pad where the kitchen has sufficient heated water to meet all normal kitchen and can-washing needs. Suitable backflow and cross connection prevention shall be provided on all water lines.

4.2.3.9 *Multiple Container Washing.* Multiple containers cannot satisfactorily be cleaned by the use of personnel at mess halls and similar facilities. The multiple container cleaning facility shall be centrally located on the route between the disposal facility and the source of refuse materials. Locate the facility where water and sewerage are conveniently available. A high-pressure (1000-1200 psi) hot water source or steam cleaner can be provided with discharging the drainage directly to the sewer. For installations requiring them, this area is also a good location for a foreign garbage steam sterilization facility.

4.2.3.10 Provide a concrete slab with proper drainage and of adequate size for the intended service and number of vehicles that may use the washing facility at the same time. The wash water from the can-washing facility needs to be collected and treated as wastewater. Shelter for the washing facility is not required. Whether using hot or cold water, a booster pump to give high pressure will facilitate washing. Fittings to introduce liquid soap or detergent into the hose stream may be desirable. Since refuse containers are considered adequately cleaned when the food particles have been removed, they do not require sterilizing. Containers used for storage of putrescible materials shall be scheduled for regular cleaning, and other containers on an as-required basis.

4.2.3.11 The same washing facility may also be used at the end of the day for washing the collection vehicles.

4.2.3.12 *Portable Cleaner.* An option to the centralized cleaning facility is a portable high-pressure cleaning system. These units will minimize capital cost expenditures but might require more labor than the central cleaning location. Portable equipment that sanitizes dumpsters, washes heavy equipment, cleans latrines, and can be used to recover liquid spills is commercially available through several sources.

4.2.4 Collection of Solid Wastes

4.2.4.1 Collection equipment and associated costs can vary depending on whether the disposal fee is based on weight or volume. If the fee is based on $\$/ft^3$, then compaction equipment can frequently be justified. The specification of collection equipment shall be a cooperative effort among: (1) the base civil engineer, (2) the procurement office, (3) the contract office, and (4) the maintenance shop. The four parties will each have different but valuable facts on price and reliability of existing equipment. All inputs are needed to specify quality replacement items.

4.2.4.2 The primary federal guideline for solid waste collection is 40 CFR 243. It specifies the collection equipment requirements, design procedures, and operating procedures. Those items are excerpted below.

Collection Equipment Requirements

> All vehicles used for the collection and transportation of solid waste (or materials which have been separated for the purpose of recycling) which are considered to be operating in interstate or foreign commerce shall meet all applicable standards established by the

federal government including, but not limited to, Motor Carrier Safety Standards (40 CFR 390-396) and Noise Emission Standards for Motor Carriers Engaged in Interstate Commerce (40 CFR 202). Federally owned collection vehicles shall be operated in compliance with Federal Motor Vehicle Safety Standards (49 CFR 500-580).

All vehicles used for the collection and transportation of solid waste (or materials which have been separated for the purpose of recycling) shall be enclosed or adequate provisions shall be made for suitable cover, so that while in transit there can be no spillage.

The equipment used in the compaction, collection, and transportation of solid waste (or materials which have been separated for the purpose of recycling) shall be constructed, operated, and maintained in such a manner as to minimize health and safety hazards to solid waste management personnel and the public. This equipment shall be maintained in good condition and kept clean to prevent the propagation or attraction of vectors and the creation of nuisances.

Collection equipment of the following types used for the collection, storage, and transportation of solid waste (or materials which have been separated for the purpose of recycling) shall meet the standards established by the American National Standards Institute (ANSI Z245.1, Safety Standards for Refuse Collection Equipment) as of the effective date(s) established in ANSI Z245.1:

- rear-loading compaction equipment
- side-loading compaction equipment
- front-loading compaction equipment
- tilt-frame equipment
- hoist-type equipment
- satellite vehicles
- special collection compaction equipment
- stationary compaction equipment.

Whenever possible, enclosed, metal, leak-resistant compactor vehicles shall be used for the collection of solid wastes.

Safety devices, including, but not limited to the following shall be provided on all collection vehicles:

- exterior rear-view mirrors
- back-up lights
- four-way emergency flashers
- easily accessible first aid equipment
- easily accessible fire extinguisher
- audible reverse warning device.

If crew members ride outside the cab of the collection vehicle for short trips the vehicle shall be equipped with handholds and platforms big enough to safeguard against slipping.

Vehicle size shall take into consideration: local weight and height limits for all roads over which the vehicle will travel; turning radius; and loading height in the unloading position to insure overhead clearance in transfer stations, service buildings, incinerators, or other facilities.

Engines which conserve fuel and minimize pollution shall be used in collection vehicles to reduce fuel consumption and air pollution.

Recommended Operation Procedures

Collection vehicles shall be maintained and serviced according to manufacturers, recommendations, and receive periodic vehicle safety checks, including, but not limited to, inspection of brakes, windshield wipers, taillights, backup lights, audible reverse warning devices, tires, and hydraulic systems. Any irregularities shall be repaired before the vehicle is used. Vehicles shall also be cleaned thoroughly at least once a week.

No person shall work, walk or stand under elevated truck/containers.

Solid waste shall not be allowed to remain in collection vehicles over 24 h and shall only be left in a vehicle overnight when this practice does not constitute a fire, health, or safety hazard.

Solid wastes (or materials which have been separated for the purpose of recycling) shall be collected with frequency sufficient to inhibit the propagation or attraction of vectors and the creation of nuisances. Solid wastes which contain food wastes shall be collected at a minimum of once during each week. Bulky wastes shall be collected at a minimum of once every 3 months.

The minimum collection frequency consistent with public health and safety shall be adopted to minimize collection costs and fuel consumption. In establishing collection frequencies, generation rates, waste composition, and storage capacity shall be taken into consideration.

When solid wastes are separated at the point of storage into various categories for the purpose of resource recovery, a collection frequency shall be designated for each waste category.

The collection of solid wastes (or materials which have been separated for the purpose of recycling) shall be conducted in a safe, efficient manner, strictly obeying all applicable traffic and other laws. The collection vehicle operator shall be responsible for immediately cleaning up all spillage caused by his operations, for protecting private and public property from damage resulting from his operations, and for creating no undue disturbance of the peace and quiet in residential areas in and through which he operates.

Records shall be maintained detailing all costs (capital, operating, and maintenance) associated with the collection system. These records shall be used for scheduling maintenance and replacement, for budgeting, and for system evaluation and comparison.

The collection system shall be reviewed on a regular schedule to assure that environmentally adequate, economical, and efficient service is maintained.

Solid waste collection systems shall be operated in a manner designed to minimize fuel consumption, including but not limited to, the following procedures.

- Collection vehicle routes shall be designed to minimize driving distances and delays.
- Collection vehicles shall receive regular tuneups, tires shall be maintained at recommended pressures, and compaction equipment shall be serviced regularly to achieve the most efficient compaction.
- Compactor trucks shall be used to reduce the number of trips to the disposal site.
- When the distance or travel time from collection routes to disposal sites is great, transfer stations shall be used when cost effective.
- Residential solid waste containers which are serviced manually shall be placed at the curb or alley for collection.
- For commercial wastes which do not contain food wastes, storage capacity shall be increased in lieu of more frequent collection.

4.2.4.3 **Collection Equipment**

4.2.4.4 Solid waste collection and transportation to the disposal site accounts for 70% to 80% of the total cost of solid waste management

(Tchobanoglous, Theisen, and Eliassen 1977). To establish vehicle and labor requirements for various systems and methods, the unit time to perform each task must be determined. Details of critical definitions and calculation procedures are given by Tchobanoglous, Theisen, and Eliassen (1977). The analysis revolves around the concept of stationary container Systems (most common practice) versus hauled container systems. The conceptual differences become apparent after examination of Figure 4-2-4A. One example analysis showed that the hauled container system could save significant collection costs for round-trip haul distances less than 10 miles.

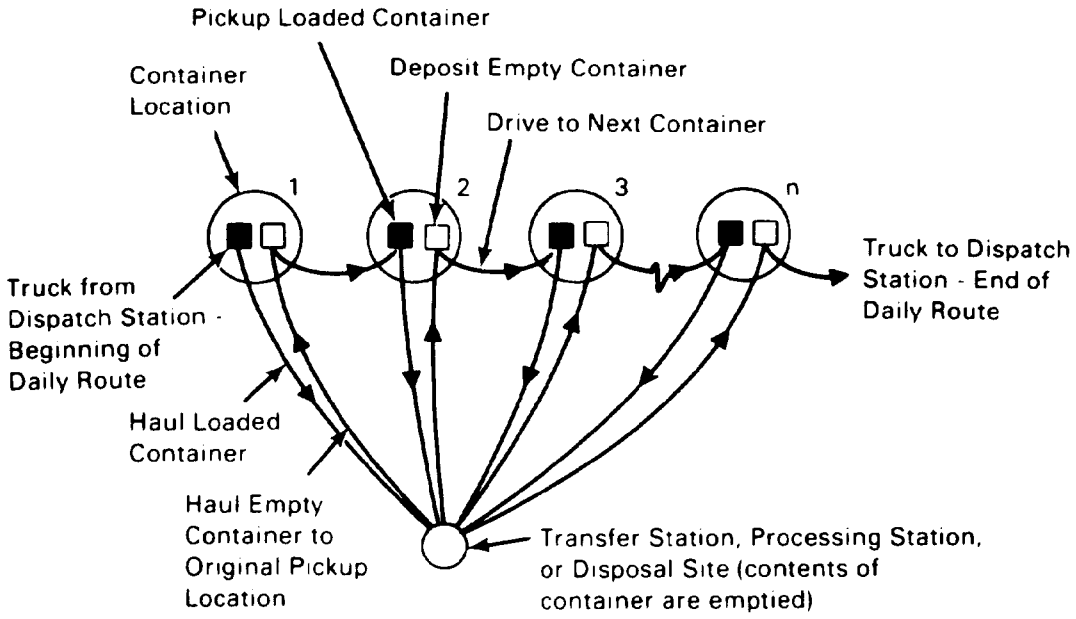
4.2.4.5 Table 4-2-4A gives size ranges for containers used in each scheme. Table 4-2-48 is a companion table and shows data on typical vehicles used in garbage collection. Figures 4-2-4B through 4-2-4G are sketches of some of the available garbage collection vehicles specified in Table 4-2-4B. The chain-lift type rear hoist truck (Figure 4-2-2G) is inefficient and is being phased out in the military. The fork-lift type, rear container hoist type truck is no longer being procured. For those remaining in service, replacement consists of ordering a cab and chassis to mount the lift mechanism on. Use of rear-loading compaction equipment depicted in Figures 4-2-2D and E is not recommended because the operation is expensive and labor-intensive. Instead, the automated side loader and container handling system in Figure 4.2.2F is recommended. Specifications for collection vehicles must be specific for the type of frame, transmission, engine, brake system, differential, and body and for specialty items such as rear-viewing TV, communications equipment, tires, and any special controls.

4.2.4.6 **Operating Records**

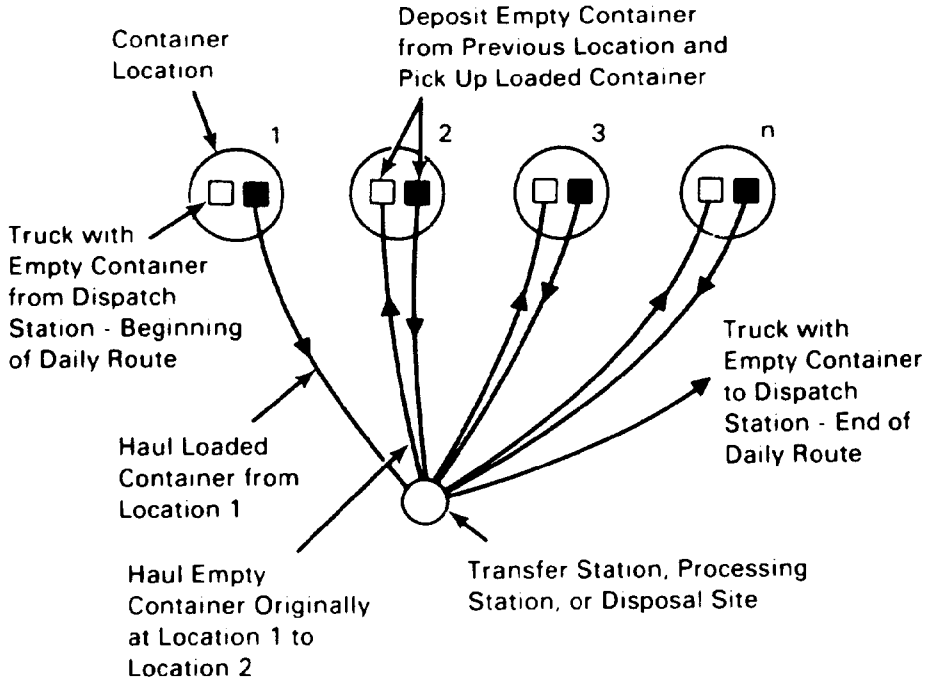
4.2.4.7 Keep accurate operating records for each collection truck assigned to the refuse collection system. Department of Army Form 3916 (Daily Log of Truck Trips for Refuse Collection and Disposal) has been designed for this purpose in the Army; Form 1453 (Refuse Collection and Disposal report) for the Air Force; the Navy does not have a standard form for this. Truck drivers fill in the form daily, noting the size of each load (full, three-quarters, one-half, or one-quarter) or number of 32-gal garbage cans carried on each trip. The supervisor collects the reports, converts the size of load to cubic yards, and makes a monthly consolidation of these data on DA Form 3917 (Refuse Collection and Disposal) for the Army, and the Air Force uses AF Form 1452, Daily Log of Refuse and Salvage Collections.

4.2.4.8 For reporting purposes, the standard workload unit for collecting refuse and salvage is the cubic yards of uncompacted material. The method for computing the quantities to be reported for each type of collection equipment is given below.

4.2.4.9 *Compaction Type.* Load the vehicle body with measured quantities of the loose refuse materials being handled at the installation, in a manner similar to the way it is loaded during the normal refuse collection operation. It is important that the materials and method be representative of the daily operations; otherwise, the compaction factor, and consequently the reported daily volumes of refuse, will be in error. The total quantity of uncompacted material that is placed in the truck body when divided by the rated (measured dimensions) capacity of the truck body will give a compaction factor for the specific materials collected and the



(a) Conventional Mode



(b) Exchange Container Mode

FIGURE 4-2-4A
Comparison of Hauled and Stationary Container Concepts

TABLE 4-2-4A
Typical Data on Container Capacities Available
for Use with Various Collection Systems

Collection		Typical Range of Container Capacities, yd^3
Vehicle	Container Type	
Hauled container systems		
Hoist truck	Used with stationary compactor	6-12
Tilt-frame	Open top, also called debris boxes	12-50
	Used with stationary compactor	15-40
	Equipped with self-contained compaction mechanism	20-40
Truck-tractor	Open-top trash-trailers	15-40
	Enclosed trailer-mounted containers equipped with self-contained compaction mechanism	20-40
Stationary container systems		
Compactor, mechanically loaded	Open top and enclosed top and side-loading	1-8
Compactor, manually loaded	Small plastic or galvanized metal containers, disposable paper, and plastic bags	20-55 (gal)

TABLE 4-2-4B
Typical Data on Vehicles Used for the Collection of Solid Wastes

Collection Vehicle			Typical Overall Collection Vehicle Dimensions				
Type	Available Container or Truck Body Capacities, yd^3	Number of Axles	With Indicated Container or Truck Body Capacity, yd^3	Width, in.	Height, in.	Length,(1) in.	Unloading method
Hauled container systems							
Hoist truck	6-12	2	10	94	80-100	110-150	Gravity, bottom opening
Tilt-frame	12-50	3	30	96	80-90	220-300	Gravity, inclined tipping
Truck-tractor trash-trailer	15-40	3	40	96	90-150	220-450	Gravity, inclined tipping
Stationary container system							
Compactor (mechanically loaded)							
Front loading	20-45	3	30	96	140-150	240-290	Hydraulic ejector panel
Side loading	10-35	3	30	96	132-150	220-260	Hydraulic ejector panel
Rear loading	10-30	2	20	96	125-135	210-230	Hydraulic ejector panel
Compactor (manually loaded)							
Side loading	10-37	3	37	96	132-150	240-300	Hydraulic ejector panel
Rear loading	10-30	2	20	96	125-230	210-230	Hydraulic ejector panel

(1) From front of truck to rear of container or truck body

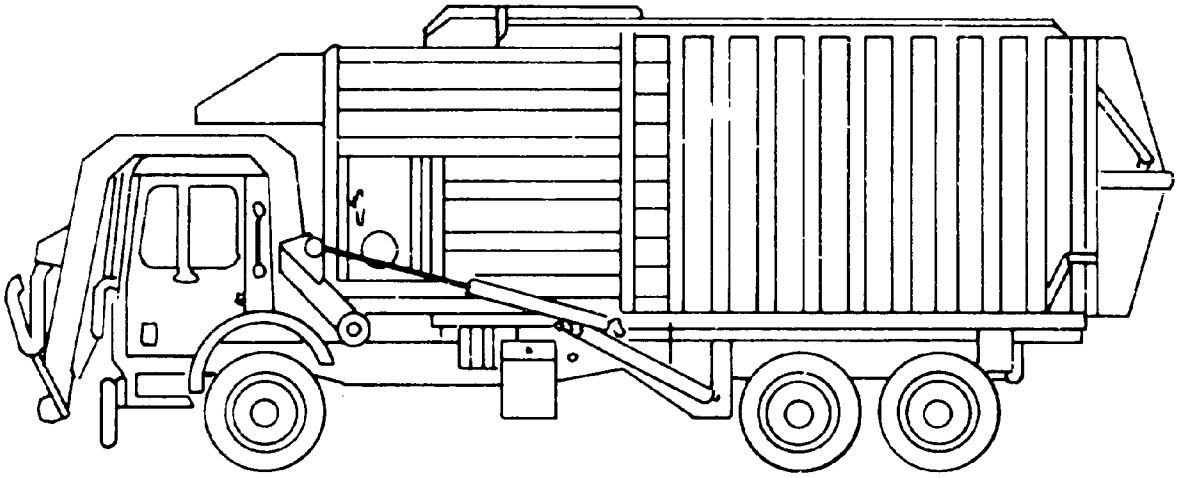


FIGURE 4-2-4B
Half/Pack Front Loader

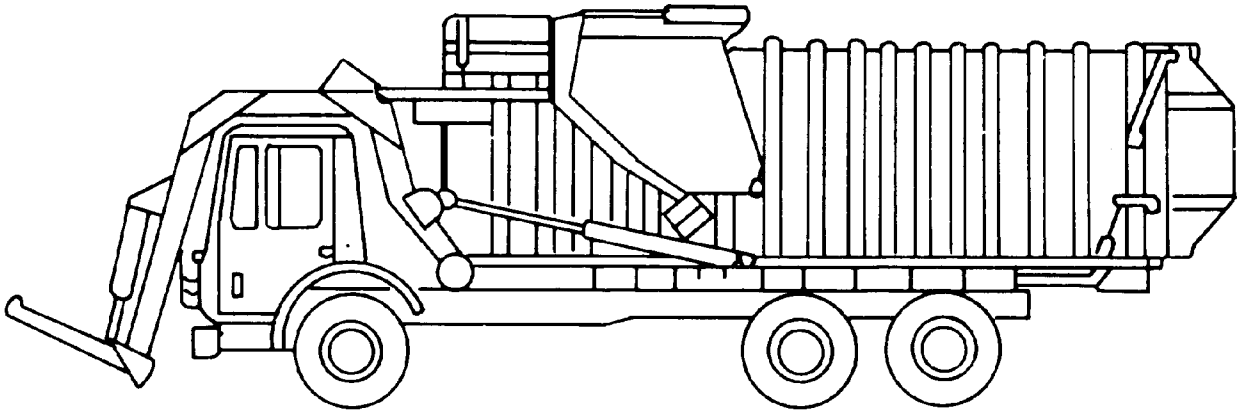


FIGURE 4-2-4C
Full/Pack Front Loader

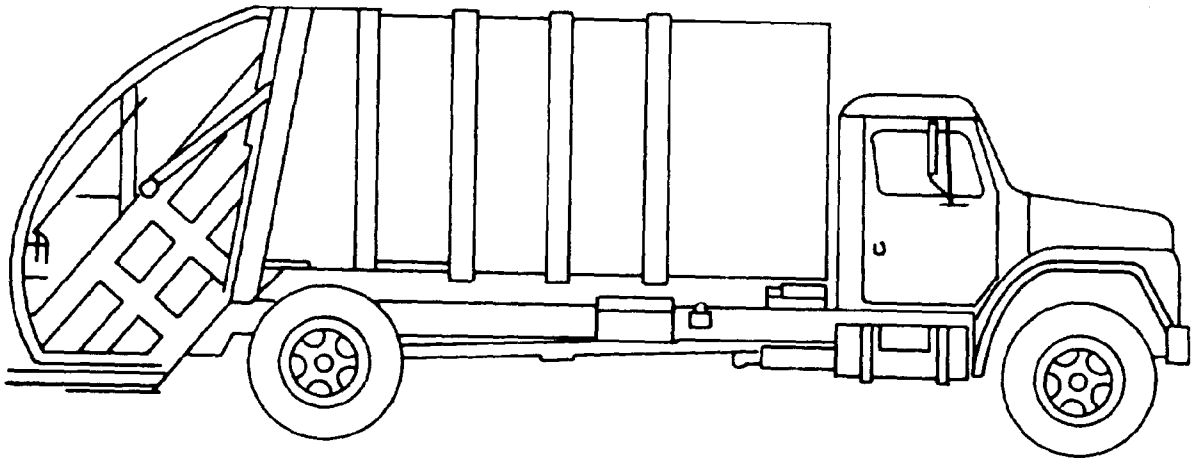


FIGURE 4-2-4D
Mid-Range Rear Loader

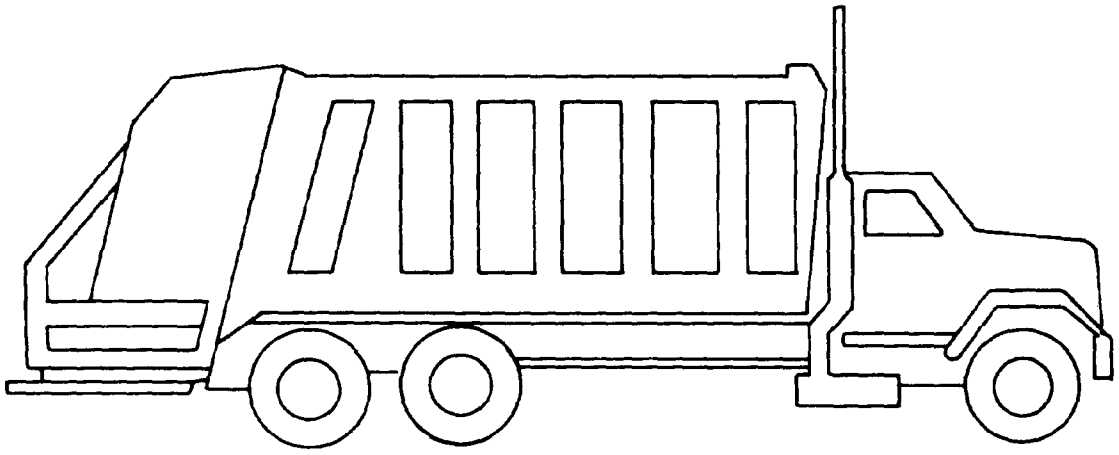


FIGURE 4-2-4E
High-Compaction Rear Loader

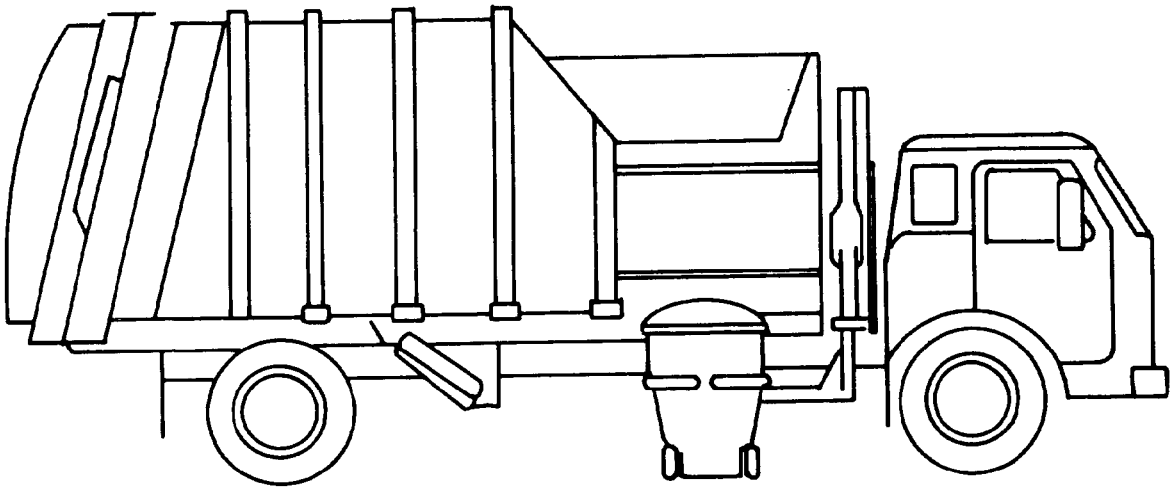


FIGURE 4-2-4F
Automated Side Loader and Container Handling System

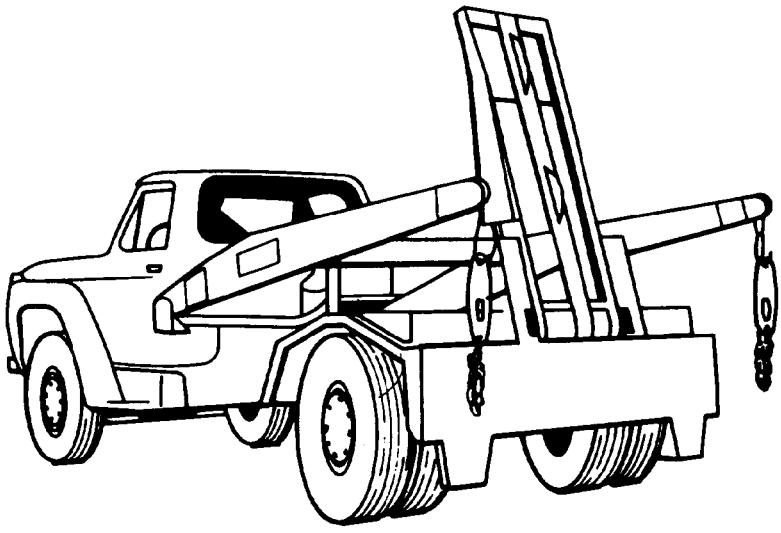


FIGURE 4-2-4G
Hoist Truck

particular truck body. This compaction factor when multiplied by the volume of material collected daily will give the cubic yards of uncompacted refuse and salvage to be reported. Obtain compaction factors for as many kinds of refuse materials as are being collected on the installation. Verify these factors periodically and as required by changes in proportions or composition of refuse and salvage materials.

4.2.4.10 *Dump trucks and multiple containers.* Since there is no compaction device on special purpose vehicles such as dump trucks or multiple containers, the measured size of each load delivered to a disposal facility or transfer station will be the reported cubic yards collected in these vehicles.

4.2.4.11 *Garbage cans, 32-gal size.* Approximately six full 32-gal garbage cans are equivalent to a cubic yard. The quantity collected in cans will be computed on the basis of the number of cans serviced and the degree to which the cans are filled.

4.2.4.12 *Periodic weighings.* Verify volumetric estimates and supply usable data when evaluating the resource recovery potential of the installation by periodically weighing containers.

4.2.4.13 **Frequency of Collection**

4.2.4.14 Depending on the rate of generation, type of waste, and other considerations, collection may be made on a scheduled route basis or on an unscheduled demand or call basis.

4.2.4.15 The following factors will be considered and evaluated to determine the frequency of collection from each pickup station:

- types of refuse materials to be collected (garbage, ashes, combustible or incombustible rubbish, or any combination thereof)
- methods of disposal (sanitary fill, incinerator, burning pit, off-post or contract disposal. and salvage collection and disposal)
- requirements of service at installations (mess hall, barracks, quarters, exchange or club, warehouse, shop, or storage facility)
- local geographical and climatic conditions (arctic, temperate, tropical, dry or humid, high or low elevation)
- season
- types of storage and collection equipment available and in use (compactor trucks or multiple container equipment).

4.2.4.16 Keep frequency of collection to the minimum possible and still maintain sanitary conditions. Recommended frequencies are

- dining facilities - daily
- family housing - once/week
- trash, ashes, debris - once/week
- industrial activities - on demand basis
- transfer stations - daily and on demand are both common.

4.2.4.17 **Collection Point**

4.2.4.18 A collection point consists of two elements: a container and a location for the container. The type, size, and location of containers shall be determined first when designing or modifying a collection system. The selection of the collection point is the responsibility of the base civil engineer.

4.2.4.19 Provide adequate and suitable containers at each pickup station. Suitable containers are cans, drums, bins, or similar portable receptacles with tight-fitting lids that contain the contents and odors. For manually hoisted containers, fully loaded container weight shall be limited to 75 lb. In selecting a site for storage containers, aesthetics is an important consideration.

4.2.4.20 Establish collection points easily accessible to collection trucks and not more than 300 ft from the source of refuse material. Provide separate stations at the following locations:

- mess halls, exchanges, clubs, and similar facilities where food is handled, stored, or dispensed
- temporary barracks
- separate family quarters
- multiple family quarters.

4.2.4.21 Curbside or service-drive solid waste collection will be used in family housing unless another system gives a cost or environmental advantage to the government. Use of other than curbside or service-drive collection must be supported by an economic or environmental analysis. It will be retained in installation records.

4.2.4.22 **Separate Collection**

4.2.4.23 When solid wastes are separated at the point of storage into various categories for recycling or resource recovery, collection frequency shall be designated for each waste category.

4.2.4.24 There are obvious advantages when all refuse can be collected at one time. Combined collections, which reduce handling and truck trips and permit maximum use of collection vehicles, are strongly recommended. The ultimate method of disposition, resource recovery potential, and the degree of separation dictate the need for separate collections. Separate collections are generally made for the following conditions:

- If incineration is used, bulky refuse items and noncombustible rubbish, such as glass, large quantities of computer cards, etc., shall be collected separately and not delivered to the incinerator.

- Solid waste that is recyclable or suitable for resource recovery shall be collected separately.

- After incinerator ashes have been quenched or sufficient time has elapsed to ensure cooling of the ashes, they shall be collected separately.

4.2.4.25 When segregation is required, materials are generally separated as follows:

4.2.4.26 *Hog-food garbage.* This operation must conform to state and local health authority requirements. Drained hog-food garbage is placed separately in covered 32-gal garbage cans. It includes kitchen leftovers, plate wastes, lettuce leaves, pea hulls, corn cobs, vegetable tops, and rinds and peelings from other than citrus fruits. This material is typically disposed of through the kitchen garbage grinder if not sold.

4.2.4.27 *Other garbage and rubbish.* All other garbage and rubbish are placed in covered 32-gal garbage cans or large multiple containers. They include drained coffee grounds, citrus fruit rinds, seafood and poultry wastes, food wrappings, carbon and stencil paper, rubbish from barracks, and similar unsalable items. When refuse is disposed of by incineration, such noncombustible materials as dirt, glass and crockery, metals, and other mineral refuse must be segregated and placed in separate containers.

4.2.4.28 *Spent cooking grease and trap grease.* These items are placed in separate covered 10- or 16-gal garbage cans. To eliminate the possibility of spilling when the cans are handled during collection, do not fill the cans more than 4 in. from the top.

4.2.4.29 *Bones and meat trimmings.* When meat cutting is performed at mess halls, bones and meat trimmings are placed in covered 32-gal garbage cans and are generally sold as salvage.

4.2.4.30 *Salvable paper, cardboard, and kraftboard.* Salvable paper items are tied and stacked at one end of the pickup station. They shall be protected from the weather because they lose salvage value once they have gotten wet.

4.2.4.31 *Separated solid waste materials.* Store so that they are not a fire, health, or safety hazard and do not provide food or harborage for disease vectors (flies, mosquitos, rodents). Contain or bundle wastes to prevent spills.

4.2.4.32 **Social Requirements**

4.2.4.33 Store solid waste containing food waste securely in covered or closed containers that are nonabsorbent, leakproof, durable, easily cleanable, and designed for safe handling.

4.2.4.34 Storage of bulky wastes shall include removing doors from large household appliances and covering the items to reduce:

- any problem of an "attractive nuisance"
- accumulation of other waste and water in and around the bulky items.

4.2.4.35 Reusable waste containers emptied by hand must not exceed 75 lb when filled. Collectors should not come in physical contact with the waste.

4.2.4.36 Procurement specifications for multiple containers shall establish conformance with DoD Military Specifications MIL-R-2395C unless such containers are unavailable or superior containers are desired.

4.2.5 Transfer and Transport

4.2.5.1 **Types of Transfer Stations**

4.2.5.2 There are several types of transfer station systems commonly employed. These are briefly described below:

4.2.5.3 *Direct Dump to Container.* This is the most basic and simple form of transfer system. This system is employed when small volumes (100 yd^3 or less) of solid wastes are handled. Container volumes range from about 15 to 55 yd^3. Full containers are replaced with empty ones, and the full container is transported to the disposal site by tilt-frame trucks. This type of system is advantageous because of low capital costs and simple loading methods. However, because of the low solid waste densities (about 200 lb/yd^3) obtained, spare containers may be required to handle incoming waste during peak periods. Also, there are potential hazards associated with this method, including leachate generation due to rainfall into the open box and the possibility of someone falling into the container while unloading the solid waste.

4.2.5.4 *Dump into Trailer.* With this method, solid waste is dumped from an elevated area into trailers instead of drop boxes. It is more commonly used than the drop box system. Trailers are available to handle up to and even over 130 yd^3. Open-top trailers are less expensive initially and require less maintenance than the alternative compactor trailer types. Disadvantages of trailer systems are the same as for the drop box systems except haul costs are less because of the larger payload. There are several methods commonly employed to feed waste into transfer trailers, including:

- *Direct Dump*. With this method, solid waste is dumped directly into the trailer from the collection vehicle from an elevated ramped area (see Figure 4-2-SA).
- *Dump to Storage Pit.* For this system, solid waste collection vehicles dump directly into a storage pit where the waste materials are crushed by crawler tractors and then pushed over

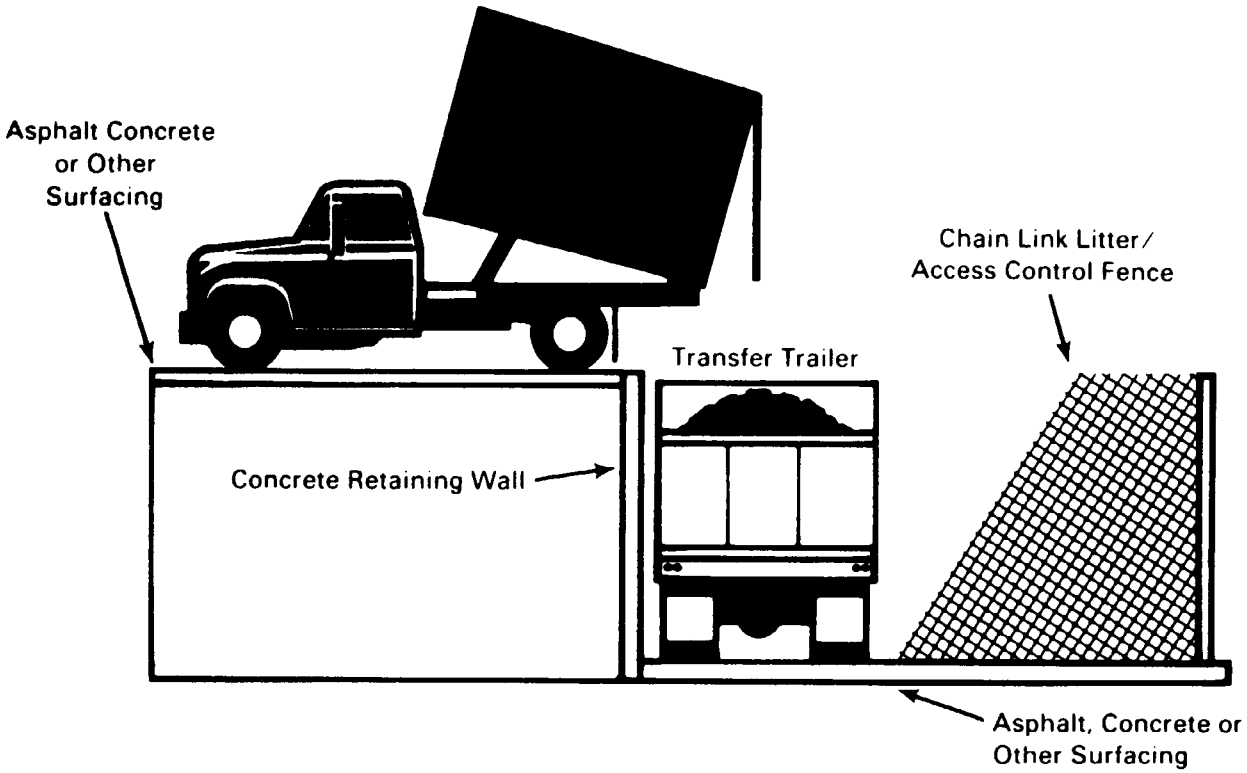


FIGURE 4-2-5A
Direct Dumping to Transfer Trailer Station

the ledge of the storage area into the trailer. This method is generally employed where solid waste quantities delivered exceed 500 yd^3 per day.

- *Dump to Tipping Floor.* This method is similar to the storage pit method, except solid wastes are dumped onto a tipping floor rather than a storage pit, crushed by crawler tractors, and pushed into the trailer (see Figure 4-2-5B). This method is used effectively when solid waste delivery rates range from 100 to 500 yd^3 per day.

4.2.5.5 Once the solid waste is in the trailer, it is generally leveled and further compacted by a backhoe or similar tamping device.

4.2.5.6 At the disposal site, various methods are used to unload the trailers, with the most efficient being the live bottom trailer. The floor of these trailers consists basically of a conveyor or other active type floorsystem which, when activated, automatically unloads the trailer.

4.2.5.7 *Dump into Hydraulic Compaction Units.* These systems are generally employed only at locations where solid waste delivery rates exceed 500 yd^3 per day. In a hydraulic compaction system, a transfer trailer is backed into position and locked to a stationary compactor firmly anchored in a concrete foundation. The compactors used are large, heavy-duty units capable of handling most materials and producing the waste densities necessary to obtain maximum legal payloads. During operation, solid waste is loaded to the compactor from a hopper and the hydraulically powered reciprocating ram of the compactor forces the refuse horizontally through the door in the rear of the transfer trailer. At the disposal site, the entire rear section of the transfer trailer is opened and the waste pushed out by an ejection ram. Because this system requires that the transfer trailer be attached to the compactor, any hydraulic compaction system prohibits the use of drive-through arrangements.

4.2.5.8 There are several methods of feeding waste to the compactor hopper:

- direct dump into the hopper
- dump into a hydraulic push-pit equipped with a hydraulically activated ram which automatically feeds waste into the hopper
- dump into a storage pit or tipping floor where waste is crushed and pushed into the hopper by a wheel loader or crawler tractor
- dump into an inclined conveyor which automatically feeds waste into the hopper.

4.2.5.9 Table 4-2-SA presents a summary of transfer station systems available for use at military installations, including advantages and disadvantages of each system.

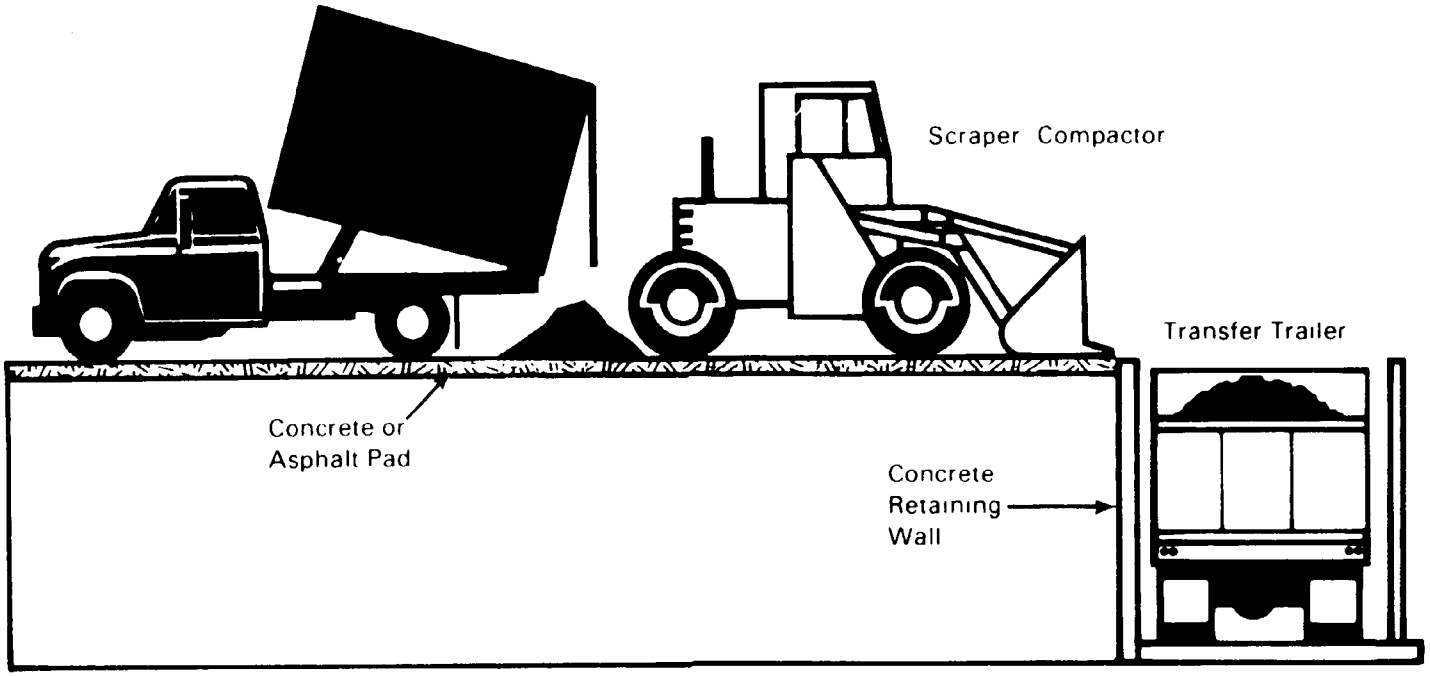


FIGURE 4-2-5B
Direct Dumping to Tipping Floor Transfer Station

TABLE 4-2-5A
Transfer Station Types

Type	Volumne of Solid Waste Most Economically Handled	Generally Applicable at Military Installations	Advantages	Disadvantages
Noncompacting:				
Direct Dump to Container	Up to 100 yd^3/day	Yes	Low capital costs, simple unloading, low operation and maintenance costs.	Low solid waste densities, potential leachate due to rainfall in open box.
Direct Dump to Trailer	Up to 100 yd^3/day	Yes	Same as for direct dump to container except costs are lower because of larger payloads.	Same as for direct dump to container.
Dump to Storage Pit	Over 500 yd^3/day	No	Can efficiently handle large volumes of solid waste; simple unloading, haul costs low because of large payloads,	Operation maintenance costs higher than above systems; potential for person falling into pit.
Dump to Tipping Floor	Over 100 yd^3/day	Yes	Same as dump to storage pit except capital costs are lower.	Same as dump to storage pit except there is no potential for falling into pit.
Compacting:				
Dump into Hydraulic Compaction Unit	Over 500 yd^3/day	No	Haul costs low because of compacted payloads, little or no exposure of waste to atmosphere.	If compactor fails no way to load trailers, high capital cost, someone could fall into compaction unit, no way to have drive-thru arrangements.
Dump to Inclined Conveyor	Over 500 yd^3/day	No	Can handle large volume of waste,	Same as direct dump to trailer and dump to compaction unit, except no one could fall into pit or compaction unit.

4.2.5.10 **Environmental Impacts.** The environmental impacts associated with the transfer and hauling of unprocessed solid waste include

- noise
- air quality
- odor
- traffic congestion
- litter
- insects and rodents
- water contamination.

4.2.5.11 *Noise.* Sources of noise at the transfer station include the operation of collection and transfer vehicles, and any loading and/or compacting/tamping equipment.

4.2.5.12 *Air Quality.* Air quality impacts include idling of collection vehicles during dumping operations, exhaust from operation of front end loaders or crawler tractors, and dust generated by the unloading of collection vehicles and haul vehicles. Site users/workers are exposed to dust especially when stations are enclosed; however, an enclosed station decreases the impacts on the surrounding community.

4.2.5.13 *Odors.* Objectionable odors can occur when mixed solid waste containing organic matter accumulates in an environment conducive to putrefaction. To minimize odors, the waste receiving area at the transfer station shall be designed and staffed to handle peak day loads with adequate time for a thorough daily cleanup.

4.2.5.14 *Traffic Congestion.* Traffic to and from the transfer station may cause congestion on nearby streets and intersections. Also, haul operations can cause significant congestion thereby slowing station operations. Scheduling of collection and transfer truck trips to avoid peak traffic hours can reduce this problem.

4.2.5.15 *Litter.* The site shall be fenced to contain any blowing litter, and a daily litter cleanup procedure shall be included in the operation plan. All solid waste transferred to and unloaded at the site shall be covered to minimize the problem. Haul trailers do not generally contribute to littering because the solid waste is usually compacted or completely contained inside the truck.

4.2.5.16 *Water Contamination.* Water pollution impacts stemming from rainfall into the transfer containers or washdown of the transfer station area and of the transport vehicles can be mitigated by collecting and channeling runoff waters to a sewer system, or by collecting and treating the runoff prior to disposal. The potential for water pollution during the haul operation is insignificant.

4.2.5.17 **Transfer Station Siting**

4.2.5.18 Factors to consider when evaluating alternative transfer station sites, include the following:

1. type of transfer system to be employed

2. collection and transfer vehicle access

3. availability of proposed site for use as a transfer station

4. size of site required for initial transfer station operations and for possible future expansion of transfer station operations or construction of resource recovery facilities

5. proposed future surrounding land use

6. existing facilities adjacent to proposed site

7. environmental impacts (e.g., visual, odors, etc.)

8. foundation conditions

9. central to existing and proposed future collection areas

10. proximity to existing or projected future disposal location

11. permitting requirements.

4.2.5.19 These factors can be used in establishing criteria for judging the relative merits of each alternative site.

4.2.5.20 **Permitting.** Items 2 and 9 are the most important considerations. Permitting requirements vary from state to state. In some states permits are not yet required. In others (e.g., New Jersey) transfer stations are viewed as waste disposal sites. Procedurally, permitting the transfer stations is no different than permitting a landfill, incinerator, or recycling center. Less total paperwork may be required for establishing a transfer facility, but the number of steps is the same.

4.2.5.21 **Transfer Station Costs**

4.2.5.22 The following cost factors must be considered:

Capital Costs

- building
- land
- transfer tractors and trailers
- wheel or track loader
- leveling and tamping equipment.

Annual Costs

- transfer vehicles
  - operation & maintenance (0&N)
  - taxes, licenses, and insurance

- labor
- building amortization
- transfer station 0&M (e.g., utilities, etc.)
- transfer station equipment 0&M (e.g., track dozer).

4.2.5.22 Once these costs are developed, a comparison between direct haul and collection vehicle can be made and the most viable system selected. Figure 4-2-SC presents a generic graph of a cost comparison between direct haul and transfer haul.

4.2.6 Sanitary Landfill Design and Operation

4.2.6.1 *General.* Sanitary landfilling is an engineered solid waste disposal process which minimizes the environmental hazards and nuisances of land disposal. Solid waste is delivered to a carefully selected and prepared site, deposited into a trench or controlled area, compacted, and covered with soil or other material daily. Landfills must conform to EPA and/or state requirements. Potential regulations at the state and federal level would require double liners with leachate collection and groundwater monitoring for all new landfills.

4.2.6.2 Sanitary landfills have advantages not common to most other methods of refuse disposal: they do not require large operating crews; they can receive all categories of solid wastes, except hazardous waste; they can accommodate large fluctuations in the daily accumulation of refuse without additional personnel or equipment; and they provide reasonable control of vectors and pollution.

4.2.6.3 The sanitary landfill is capable of accepting a wide variety of solid waste types. Nearly all rubbish, garbage, trash, ashes, solid organic waste, and miscellaneous solids may be disposed of safely. Most domestic-type solid waste can be disposed of without presorting, or in combination with the following solid waste reduction techniques: incineration, baling, compacting, or shredding.

4.2.6.4 Certain waste products are not appropriate for sanitary landfill operations. These include hazardous waste; toxic substances; liquids; untreated infectious waste; and volatile, explosive, or flammable wastes. Measures shall be taken to ensure that these solid waste products are not delivered to the landfill site. Plans for separation and removal of accidental deliveries shall be kept current.

4.2.6.5 *Sanitary Landfill Design.* The objectives of a landfill design are to (1) ensure compliance with pertinent regulatory guidelines/ requirements; (2) provide adequate present and long-term protection of the environment; (3) achieve cost-efficient utilization of site manpower, equipment, volume, and soil; and (4) direct and guide operators toward proper construction and operation of the landfill. This section provides guidance on design considerations for a sanitary landfill to achieve these objectives.

4.2.6.6 *Regulations and Permits.* Many regulatory and approving agencies require permits before a landfill can be constructed or operated. A conceptual landfill design is generally an integral part of the application

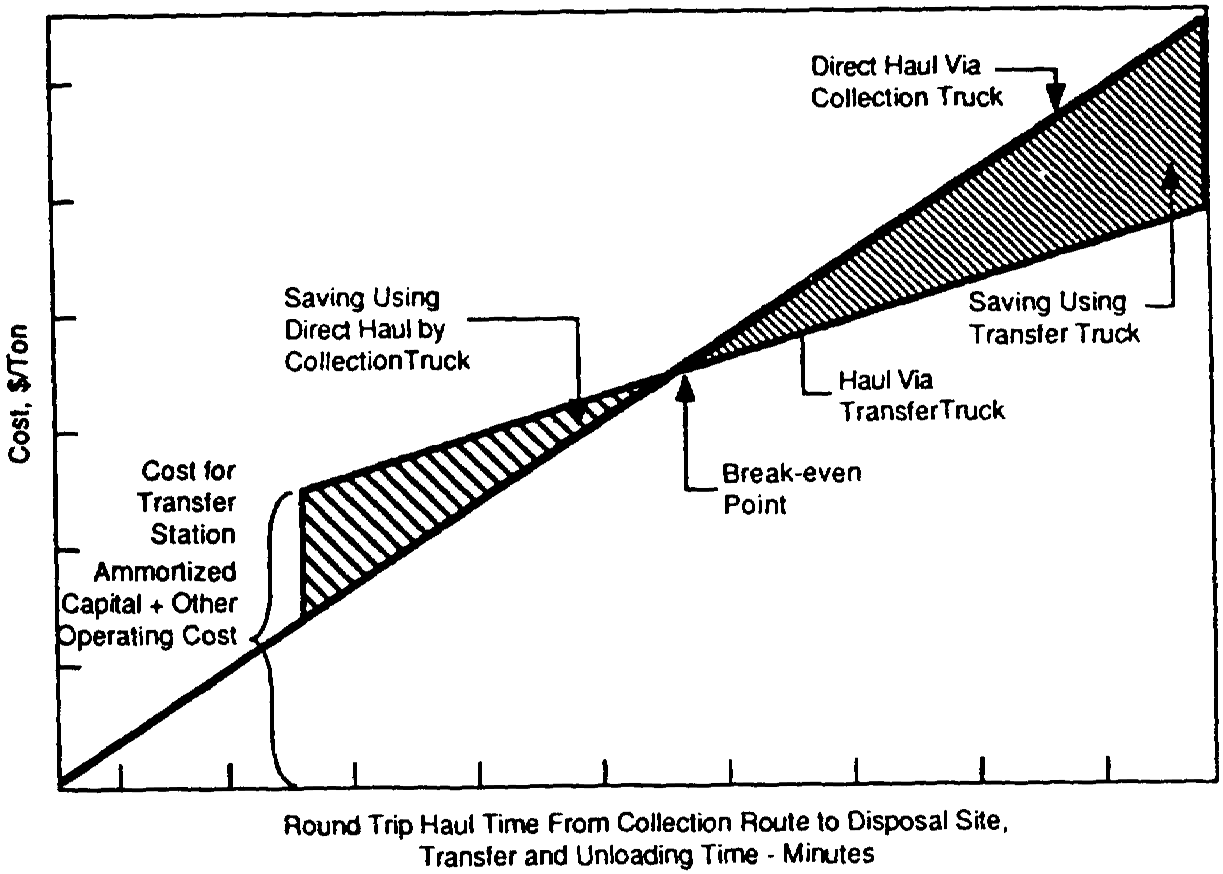


FIGURE 4-2-5C
Comparison of Direct Haul and Transfer Haul Costs

for such permits. Accordingly, all pertinent agencies shall be contacted early in the design phase to take the following steps:

- identify regulations impacting on the prospective landfill
- determine the extent, detail, and format of the application
- obtain permit application forms and other background information.

4.2.6.7 Two permits relevant to landfills are identified and mandated by these criteria:

1. NPDES (National Pollutant Discharge Elimination System) permit (402 and 404) required for location of a landfill in waters of the United States. It is also required for any point source discharges from sanitary landfills, such as from leachate collection systems.

2. Army Corps of Engineers permit required for the construction of any levee, dike, or other type of containment structure to be placed at a sanitary landfill located in waters of the United States.

4.2.6.8 Permit requirements of state and local regulations vary depending on jurisdiction. In some areas, only one permit is needed. Other states may require several separate permits or stipulate that a new sanitary landfill proponent coordinate with several agencies.

4.2.6.9 Sanitary landfill regulations can be the responsibility of one or more state agencies. Appendix D lists the various state agencies (including addresses and telephone numbers) responsible for solid waste disposal activities in those states.

4.2.6.10 Local regulatory agencies may include one or more of the following:

- environmental and health departments
- planning and/or zoning commissions
- board of county commissioners
- building departments
- highway departments
- fire departments.

4.2.6.11 The reviewing agency may require the submittal of information on standard forms or in a prescribed format in order to facilitate the review process. This process can take at least 1 month and usually 6 to 12 months or longer, depending on the degree of controversy and opposition. After a permit is issued, it can be valid for various durations, depending largely upon the submittal of monitoring results and performance reports and the results of periodic onsite inspections.

4.2.6.12 *Site Selection.* Selection of an appropriate site on the installation is the most critical step in establishing a sanitary landfill facility. Site selection criteria shall include cost, availability of land, availability of cover material, impact on natural resources (i.e., wildlife, endangered species, ecological sensitivities, etc.), topographic features and hydrogeologic considerations, environmental and pollution hazards, and social

and aesthetic consideration. The process of site selection shall involve specialists from military, local, state, and federal agencies as appropriate.

4.2.6.13 *Site characteristics.* Various sites on an installation may be available for sanitary landfill operations. These sites shall be screened by the facilities engineer to determine which is the most advantageous, using various site characteristics.

1. *Land availability.* Installation planning documents shall be consulted in order to screen the sites. Also, legal considerations, including the investigation of legal burdens, title restrictions, and other possible jurisdictional blocks to the use of various sites for landfill operations, shall be reviewed. Land area requirements vary significantly with the type of landfill operation and characteristics of land, compaction, and volume of waste generated by the installation. Figure 4-2-6A provides estimates of volume of compacted solid waste.

2. *Cover material availability.* Consider the availability and suitability of cover materials. Most well-graded soils are suitable for daily cover, but not for intermediate or final cover and should exist at the site or be immediately available to the site. The quantity of cover material will vary with the design characteristics of the site. Typical waste:cover ratios of 4:1 to 2:1 are used.

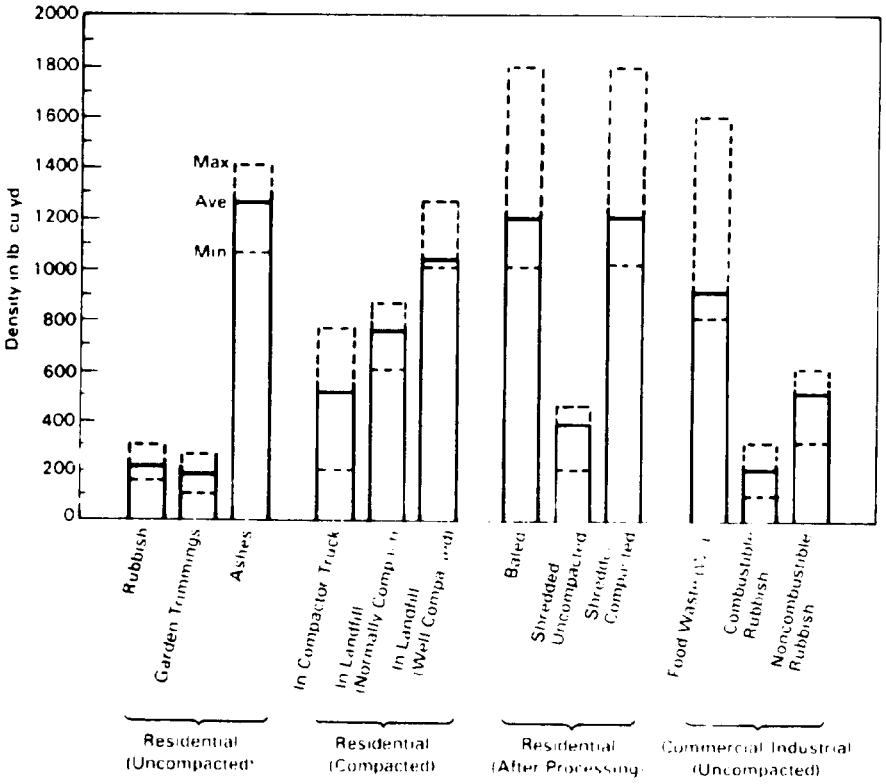
3. *Proximity.* Landfill siting shall constitute a balance between adequate distance from housing and work areas and economical hauling distances. The landfill shall be sited at least 750 ft from inhabited buildings and so that prevailing winds are away from living areas, where practical. Also, landfills must not be sited within 10,000 ft of any point of any airfield servicing jet aircraft or within 5000 ft of an airfield servicing only piston aircraft.

4. *Roads.* Sites shall be accessible to appropriate vehicles by all-weather roads leading from the public road system.

5. *Underground structures.* Sites traversed by pipelines or conduits for sewage, stormwater, etc., shall be rejected unless the relocation or protection of the pipelines or conduits is feasible. These pipelines may serve as pathways for gas and leachate. Plans for maintenance and repair of protected pipelines must be developed.

6. *Flood plains.* Landfills cannot be sited within the 100-year flood plain.

4.2.6.14 Topography. Specialists shall evaluate alternative sites from the viewpoint of pollution hazards and possible environmental degradation. Military agencies and laboratories such as the Facilities Housing Support Agency, U.S. Army Construction Engineering Research Laboratory, Naval Civil Engineering Laboratory, Naval Energy and Environmental Support Activity, U.S. Army Waterways Experiment Station, U.S. Army Environmental Hygiene Agency, Air Force Engineering and Services Center, and others can provide additional technical guidance in these areas.



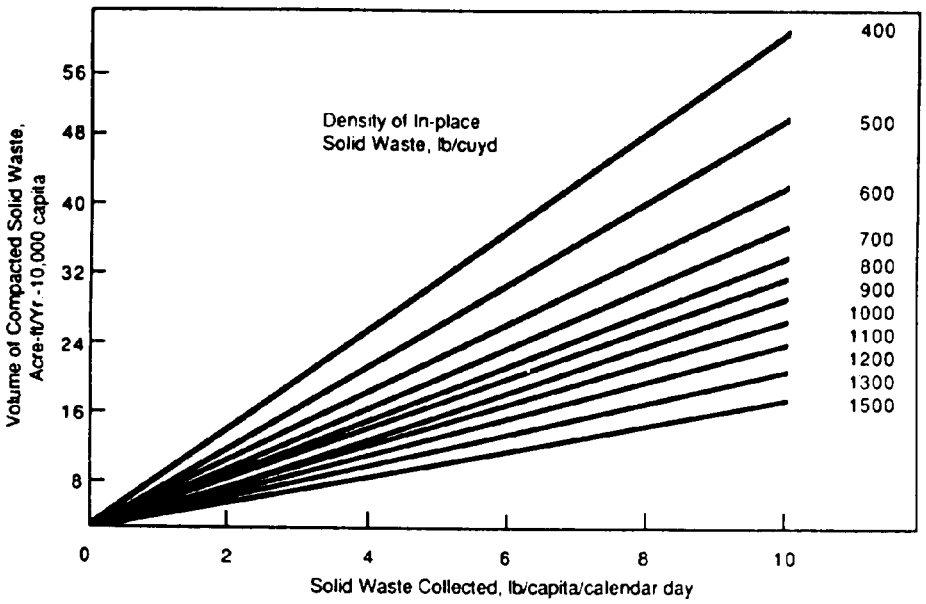


FIGURE 4-2-6A
Determining the Yearly Volume of Compact Solid Waste

1. *Surface water.* Surface water that infiltrates the cover soil can increase the rate of waste decomposition and eventually cause leachates to leave the solid waste and create water pollution problems. This problem can be minimized by rejecting sites containing surface water features, diverting upland drainage, and designing facilities with sufficient grade and slope to allow surface water runoff. Sites shall be selected on. the basis of a geohydrological evaluation of surface water problems.

2. *Terrain.* A sanitary landfill can be constructed on virtually any terrain; however, some land features require extensive site improvements and expensive operational techniques. The best terrain consists of flat or gently rolling land not subject to flooding. While depressions such as canyons and ravines are more efficient than flat areas, cover material may not be available. Also, special difficulties may occur in depressions and control of surface waters may be difficult. Such manmade features as strip mines, quarries, and open pit mines can often be safely and economically reclaimed by the government as sanitary landfills. Some offer excellent protection against leachate pollution, while others require more extensive improvements. Terrain features that shall exclude a site for consideration include the following:

   a. hilltops and other similar land forms

   b. highly permeable and porous areas such as gravel beds

   c. swamps and marshes

   d. natural drainage channels

   e. wildlife sanctuaries

   f. floodplains

   g. land having karst features such as limestone formations which can lead to the formation of sinkholes and depressions

   h. steep slopes.

4.2.6.15 **Hydrogeological Characteristics**

4.2.6.16 Liner Systems: Soil and Membrane (Robinson 1986). Both the need to protect the environment and regulatory agency requirements have resulted in the installation of liners at the base of many landfills. The liner's purpose is to limit the movement of leachate through the base of the landfill and into the underlying formations. Many materials and techniques have been tried in an effort to prevent leakage at a reasonable cost.

4.2.6.17 The liner must endure chemical and physical attack mechanisms. Many chemicals found in leachate have the potential to damage liner materials. Also, the liner must not fail structurally during installation or from the strain of the solid waste.

4.2.6.18 Liner materials include soils and, in particular, clay soil, admixed liners, flexible polymeric membranes, sprayed-on linings, soil sealants, and chemical absorptive liners. The purpose of the liner is to prevent the movement of water and its associated contaminants through the base of the landfill and into the underlying formations. The liner may be fabricated in one of two ways. It may be constructed onsite, such as when soil materials are placed and compacted, or it may be a manufactured flexible membrane placed on the site during construction.

4.2.6.19 Many landfills have had clay liners placed at their base. Clay minerals may be kaolinite, illite, or montmorillonite. A typical clay will contain one or more of these clay minerals and possibly will be mixed with other fine-grained soil materials such as silt. Clay minerals have a low hydraulic conductivity and therefore will significantly retard the movement of any leachate through them. Permeabilities for most soils containing greater than 25% clay are in the range of 10^{-8} cm/s to 10^{-5} cm/s.

4.2.6.20 Clay liner thicknesses of 5 ft (1.5 m) or greater have been required at some sites. The success of the clay liner will not only depend upon its original characteristics, but also upon the method of liner installation. Best results are achieved by placing several individual layers or lifts. Each lift is compacted before the next layer is placed. The degree of compaction achieved will be a function of the compacting equipment, the thickness of the lift, and the moisture content of the soil. The soil moisture content is a significant factor. Soil that is either too dry or wet will be less than optimum for compaction.

4.2.6.21 Admixed liners are formed-in-place liners. These include asphalt concrete, soil cement, soil asphalt, and bentonite clay liners. The liners are formed by mixing the lining material with the natural soil at the base of the landfill. The resultant mixture hardens or modifies the characteristics of the soil material to provide a low-permeability barrier. Each of these approaches has been employed successfully in the lining of impoundments.

4.2.6.22 Flexible polymeric membranes are manufactured materials that are 0.020 to 0.120 in. (0.51 to 3.0 mm) thick. The liner material is manufactured in rolls that are 48 to 96 in. (1.2 to 2.4 m) wide and hundreds of feet long. A uniform bedding material, such as sand, is placed at the base of the landfill prior to the installation of the liner. The particle size of the subgrade material usually should be less than 3/4 in. (19 mm). The base grade on the liner should be a minimum of 2% if gas release from materials beneath the liner is anticipated. Gas vents may also be necessary in order to adequately allow release. The liner is installed by unrolling the sheets of plastic and then using specialized equipment to form bonded seams between the individual sheets. The liner is usually extended up the side of the landfill to the ground surface where it is anchored.

4.2.6.23 Soil sealant and chemically absorptive liners are two other approaches that have been used on a limited basis for retarding the movement of the materials through the base of impoundments. These approaches are also being tested for use in landfills.

4.2.6.24 *Groundwater.* Groundwater pollution hazards are determined by examining annual fluctuations in the depth of the water table. A site

shall be rejected if the highest historical level of the water table is too close to the lowest point of the sanitary landfill. This condition is usually specified by state regulations/guidance or during permit review. Because the conditions affecting groundwater problems are so complex, it is essential that investigation of the landfill site include an evaluation by a qualified groundwater hydrologist.

4.2.6.25 *Soil.* Soil conditions must be suitable for preventing groundwater pollution, for excavating and covering the fill, and for vehicle access. Most soil types can be used for cover material; however, well-graded soils are preferable to other types because of better compactability and workability in all weather conditions. The most ideal soils are silt and clay soils, which restrict leachate and gas movement. Peat, granular, and highly organic soils shall not be utilized for landfills because they contain a large amount of voids and are difficult to compact. Types of materials used for cover material are dependent on the type of leachate control system used in the landfill. Final cover may consist of soils, natural or synthetic liners, or chemically or physically amended earthen materials underlying at least 6 in. of topsoil or other soil that will sustain the growth of vegetation. The cover material shall have a permeability of 1×10^{-5} to 1×10^{-7} cm/s. Federal and state regulations shall be consulted to determine the exact requirements for the specific state in which the landfill is located.

4.2.6.26 *Other considerations.* The relationship of the potential landfill site to other installation activities must be considered.

1. *Aircraft.* Sites shall not be located in the vicinity of military or civilian airfields, where birds attracted to the landfill facility could pose a hazard to aircraft. Birds are dangerous to aircraft because they can ruin jet engines and cause aircraft to crash. The proper distances from an airport runway can be obtained from federal/state regulations or guidance. A landfill shall not be located with 10,000 ft of the closest point of any runway at any airport subject to regulation by the Federal Aviation Administration (FAA) which may be used by turbo-jet aircraft or within 5000 ft of any runway of any such airport used only by piston engine type aircraft unless it has been determined by the FAA that the proposed landfill poses no safety hazard to aircraft in the vicinity. State regulations should also be consulted as they may be more restrictive than FAA regulations.

2. *Social consideration.* Potential socioeconomic effects of a site should be determined. Sites shall be selected away from human activity where possible to avoid odor and noise nuisances, litter, and public safety hazards associated with the landfill site and traffic.

3. *Utilities.* The site shall have access to electricity, sanitary services, and water. Telephone or radio communications are also desirable.

4.2.6.27 **Methodology**

4.2.6.28 Adherence to a carefully planned sequence of activities to develop a landfill design minimizes project delays and expenditures. A

checklist of design activities is presented in Table 4-2-6A, to aid in planning the design effort. These activities are listed in their general order of performance, but the order can vary considerably from site to site and from jurisdiction to jurisdiction, depending on specific conditions.

4.2.5.29 As shown in Table 4-2-6A, initial tasks consist of compiling existing information and generating new information on solid waste characteristics and site conditions. A listing of possible sources for existing information is shown in Table 4-2-6B. A summary of methods to obtain new information is shown in Table 4-2-SC.

4.2.6.30 Throughout the design phase, it is advisable to periodically contact regulatory agency representatives to ensure that the design will meet any new requirements and procedures for permit application submittals. (A sample of documentation requirements for the State of Virginia Is included in Appendix A.) Maintenance of close liaison with state and local regulatory officials throughout the design effort is normally helpful in securing a permit without excessive redesigns, especially at a time when environmental protection legislation and regulations are rapidly changing.

Two general types of design packages are prepared for a sanitary landfill:

1. Conceptual (preliminary) design plan

2. Construction design plan and specifications.

4.2.6.31 Conceptual design plans normally consist of the following elements provided in sufficient detail to describe proposed filling plans to regulatory agencies and the public. The conceptual design can also serve as a guide for landfilling operations in the event that design construction drawings are not required.

1. Conceptual design plans include:

    a. An installation map showing existing site conditions. The map shall be of sufficient detail, with contour intervals of 1 ft to 5 ft and a scale of 1 in. = 50 ft to 1 in. = 200 ft, depending on the steepness of the terrain and size of the landfill, respectively.

    b. A site preparation plan locating the areas and depths designated for cover soil excavation and soil stockpile deposits. Also shown are site facilities locations such as structures, access roads, and utilities.

    c. Development plans showing final filling and excavation contours. Development plans shall show interim (4- to 6-year) filling and excavation contours if a long-lived site is planned.

    d. Elevations showing cross sections to illustrate excavation and landfill surface development at several locations across the fill. Cross sections shall be prepared for each phase of the development plan (i.e., interim and final).

TABLE 4-2-6A
Solid Waste Landfill Design Checklist

Step	Task
1	Determine solid waste quantities and characteristics
	a. Existing
	b. Projected
2	Compile existing and generate new site information.
	a. Perform boundary and topographic survey.
	b. Prepare base map of existing conditions on-site and near-site:
	(1) Property boundaries
	(2) Topography and slopes
	(3) Surface water
	(4) Utilities
	(5) Roads
	(6) Structures
	(7) Land use.
	c. Compile hydrogeological information and prepare location map:
	(1) Soils (depth, texture, structure, bulk density, porosity, permeability, degree of compaction, moisture, ease of excavation, stability, pH, and cation exchange capacity)
	(2) Bedrock (depth, type, presence of fractures, location of surface outcrops)
	(3) Groundwater (average depth, seasonal fluctuations, hydraulic gradient and direction of flow, rate of flow, quality, uses).
	d. Compile climatological data:
	(1) Precipitation
	(2) Evaporation
	(3) Temperature
	(4) Number of freezing days
	(5) Wind direction.
	e. Identify regulations (federal, state, and local) and design standards:
	(1) Loading rates
	(2) Frequency of cover
	(3) Distances to residences, roads, and surface water
	(4) Monitoring
	(5) Roads
	(6) Building codes
	(7) Contents of application for permit.

TABLE 4-2-6A
(cont'd)

Step	Task
3	Design filling area: a. Select landfilling method based on: (1) Site topography and slopes (2) Site soils (3) Site bedrock (4) Site groundwater. b. Specify design dimensions: (1) Trench width, depth, length (2) Cell size (3) Cell configuration (4) Trench spacing (5) Fill depth (6) Interim cover soil thickness (7) Final cover soil thickness. c. Specify operational features: (1) Use of cover soil (2) Method of cover application (3) Need for imported soil (4) Equipment requirements (5) Personnel requirements (6) Asbestos burial area (7) Special waste disposal.
4	Design facilities: a. Leachate controls b. Gas controls c. Surface water controls d. Access roads e. Special working areas f. Structures g. Utilities h. Fencing i. Lighting j. Washracks k. Monitoring wells 1. Landscaping m. Debris control n. Methane collection and controls o. Liner and leak detection system p. Fire fighting q. Scales.

TABLE 4-2-6A
(cont'd)

Step	Task
5	Prepare design package: a. Develop preliminary site plan of fill areas b. Develop landfill contour plans (1) Excavation plans - including benches (2) Sequential fill plans (3) Completed fill plans (4) Fire, litter, vector, odor and noise controls. c. Compute solid waste storage volume, soil requirement volumes, and site life d. Develop final site plan showing: (1) Local area (2) Normal fill areas (3) Special working areas (4) Leachate controls (5) Gas controls (6) Surface water controls (7) Access roads (8) Structures (9) Utilities (10) Fencing (11) Lighting (12) Washracks (13) Monitoring wells (14) Landscaping (15) Debris or litter controls (16) Prevailing winds. e. Prepare elevation plans with cross sections of: (1) Excavated fill (2) Completed fill (3) Phased development of fill at interim points. f. Prepare construction details: (1) Leachate controls (2) Gas controls (3) Surface water controls (4) Access roads (5) Structures (6) Monitoring wells (7) Debris or litter controls.

TABLE 4-2-6A
(Cont'd)

Step	Task
5 (cont'd)	g. Prepare ultimate land use plan (take into account future use of land when filling is complete):
	h. Prepare cost estimate
	i. Prepare design report
	j. Prepare Environmental Assessment
	k. Submit application and obtain required permits
	1. Prepare operator's manual.

TABLE 4-2-6B
Sources of Existing Information

General Information	Specific Information	Source
Base Map	General	County road department
		City, county, or regional planning department
		U.S. Geological Survey (USGS) office or outlets for USGS map sales (such as engineering supply stores and sporting goods stores)
		U.S. Department of Agriculture (USDA), Soil Conservation Service (SCS), surveyors and aerial photographers in the area
	Topography and Slopes	USGS topographic maps
		USDA, ARS (Agricultural Research Service), SCS aerial photos
	Land Use	City, county, or regional planning agency
	Vegetation	County agricultural department
		Agriculture department at local university
Soils	General	USDA, SCS, district managers, Local Extension Service
		USGS reports
		Geology or Agriculture
		Department of local university
Bedrock	General	USGS reports
		State Geological Survey reports
		Professional geologists in the area
		Geology Department of local university
Groundwater	General	Water supply department
		USGS water supply papers
		State or regional water quality agencies
		USDA, SCS
		State or federal water resources agencies
		Local health department

TABLE 4-2-6C
Field Investigations for New Information General

Information	Specific Information	Method and Equipment
Base Map	Property boundaries	Field survey via transit
	Topography and slopes	Field survey via alidade
	Surface water	Field survey via alidade
	Utilities	Field survey via alidade
	Roads	Field survey via alidade
	Structures	Field survey via alidade
	Land use	Field survey via alidade
	Vegetation	Field survey via alidade
Soils	Depth	Soil boring and compilation of boring log
	Texture	Soil sampling and testing via sedimentation methods (e.g., sieves)
	Structure	Soil sampling and inspection
	Bulk density	Soil sampling and testing via gravimetric, gamma ray detection
	Porosity	Calculation using volume of voids and total volume
	Permeability	Soil sampling and testing via piezometers and lysimeters
	Moisture	Soil sampling and testing via oven drying
	Ease of excavation	Test excavation with heavy equipment
	Stability	Test excavation of trench and loading of sidewall or Hveem stabilimeter
	pH	Soil sampling and testing via pH meter
	Cation exchange capacity	Soil sampling and testing
Bedrock	Depth	Boring and compilation of boring log
	Type	Sampling and inspection
	Fractures	Field survey via alidade or Brunton
	Surface outcrops	Field survey via alidade or Brunton
Groundwater	Depth	Well installation and initial readings
	Seasonal fluctuations	Well installation and year-round readings

TABLE 4-2-6C
(cont'd.)

General Information	Specific Information	Method and Equipment
	Hydraulic gradient	Calculation based on permeability and hydraulic gradient
	Quality	Groundwater sampling and testing
	Uses	Field survey via Inspection
Climatology	Precipitation	Rain gauge
	Evaporation	Class A evaporation pan
	Temperature	Standard thermometer
	No. of freezing days	Minimum-maximum temperature thermometer
	Wind direction	Wind arrow

e. Groundwater monitoring well locations, depths, and configurations.

f. Details illustrating the types and locations for site facilities and nondimensioned configurations to be used, including draining structures, liners, gas control vents, and onsite roads.

g. Conceptual site closure plan indicating the types of vegetation to be used for final site landscaping, onsite appurtenances, and other improvements.

h. A conceptual design report, including a description of:

(1) Site conditions, including a description of existing site size, topography and slopes, surface water, utilities, roads, structures, land use, soil and groundwater, subsurface exploration data, bedrock, and climatology conditions.

(2) Design criteria including solid waste types and volumes expected, fill area dimensions, and site life.

(3) Operational procedures to be used to implement the design, including discussion of site preparation, solid waste unloading, handling, and covering procedures, as well as equipment and personnel requirements.

(4) Environmental safeguards including control of leachate, surface water, gas, blowing paper, odor, flies, etc.

(5) Initial site preparation and development steps.

(6) Site closure and post-closure monitoring/maintenance plan.

(7) Project cost estimates (generally prepared for in-house uses only).

2. Construction design plan and specifications:

Construction designs contain, at a minimum, all the elements of a conceptual design noted above. In addition, further details are provided to enable a bid package to be advertised for a contractor to fully construct all plan elements. For example, all drainage structures are completely sized; precise locations are noted by coordinates, bearing, and distance or other means; and environmental control systems, including those for leachate and landfill gas management, are fully designed. Also, a construction design package will include interim development plans showing fill surface and excavation contours, drainage structures, and road alignment at interim steps in the life of the landfill.

4.2.7 Landfilling Methods and Operations (Tchobanoglous, Theisen, and Eliassen 1977). To use the available area at a landfill site effectively, a

plan of operation for the placement of solid wastes must be prepared. Various operational methods have been developed, primarily on the basis of field experience. The methods to fill dry areas are substantially different from those used to fill wet areas.

4.2.7.1 **Conventional Methods for Dry Areas.** The principal methods used for landfilling dry areas may be classified as (1) area, (2) trench, and (3) depression. (See Figures 4-2-7A, B, and C.) In addition to these methods, which usually are used for unprocessed municipal solid wastes, landfilling using milled (shredded or compressed and baled) solid wastes is also discussed.

4.2.7.2 *Area Method.* The area method is used when the terrain is unsuitable for the excavation of trenches in which to place the solid wastes. Operationally (see Figure 4-2-7A) the wastes are unloaded and spread in long, narrow strips on the surface of the land in a series of layers that vary in depth from 16 to 30 in. Each layer is compacted as the filling progresses during the course of the day until the thickness of the compacted wastes reaches a height varying from 6 to 10 ft. At that time, and at the end of each day’s operation, a 6- to 12-in. layer of cover material is placed over the completed fill. The cover material must be hauled in by truck or earth-moving equipment from adjacent land or from borrow-pit areas.

4.2.7.3 The filling operation usually is started by building an earthen levee against which wastes are placed in thin layers and compacted. The length of the unloading area varies with the site conditions and the size of the operation. The width over which the wastes are compacted varies from 8 to 20 ft, again depending on the terrain. A completed lift, including the cover material, is called a cell (see Figure 4-2-7A). Successive lifts are placed on top of one another until the final grade called for in the ultimate development plan is reached. The length of the unloading area used each day shall be such that the final height of the fill is reached at the end of each day's operation.

4.2.7.4 If a small amount of usable cover material is available at the disposal site, the ramp variation of the area method is often used (see Figure 4-2-7B). In this method, solid wastes are placed and compacted as described for the area method and are partially or wholly covered with earth scraped from the base of the ramp. Additional soil must be hauled in, as in the area method. Because of increasing costs and the problems associated with obtaining usable cover material, the use of the ramp method must be based on a detailed economic feasibility study.

4.2.7.5 *Balefill Method.* Operation is similar to the area method except refuse is compressed and baled then stacked in the area prior to covering.

4.2.7.6 *Trench Method.* The trench method of landfilling is ideally suited to areas where an adequate depth of cover material is available at the site and where the water table is not near the surface. Typically, as shown in Figure 4-2-7C, solid wastes are placed in trenches varying from 100 to 400 ft in length, 3 to 6 ft in depth, and 15 to 25 ft in width. To start the process, a portion of the trench is dug and the dirt is stockpiled to form an

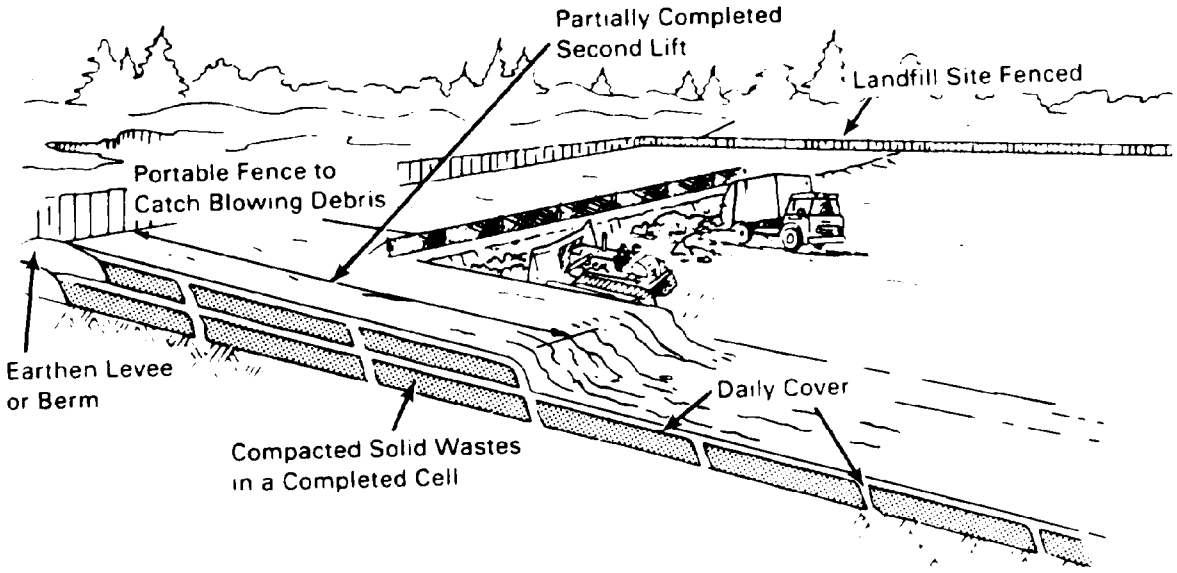


FIGURE 4-2-7A
Area Method of Operation for a Sanitary Landfill

embankment behind the first trench. Wastes are then placed in the trench, spread into thin layers (usually 18 to 24 in.), and compacted. The operation continues until the desired height is reached. The length of trench used each day shall be such that the final height of fill is reached at the end of each day's operation. The length also shall be sufficient to avoid costly delays for collection vehicles waiting to unload. Cover material is obtained by excavating an adjacent trench or continuing the trench that is being filled. The trench method, however, is not readily amenable to the proposed requirements for installation of liners and leachate collection and treatment systems.

4.2.7.7 *Depression Method.* At locations where natural or artificial depressions exist, it is often possible to use them effectively for landfilling operations. Canyons, ravines, dry borrow pits, and quarries have all been used for this purpose. The techniques to place and compact solid wastes in depression landfills vary with the geometry of the site, the characteristics of the cover material, the hydrology and geology of the site, and the access to the site.

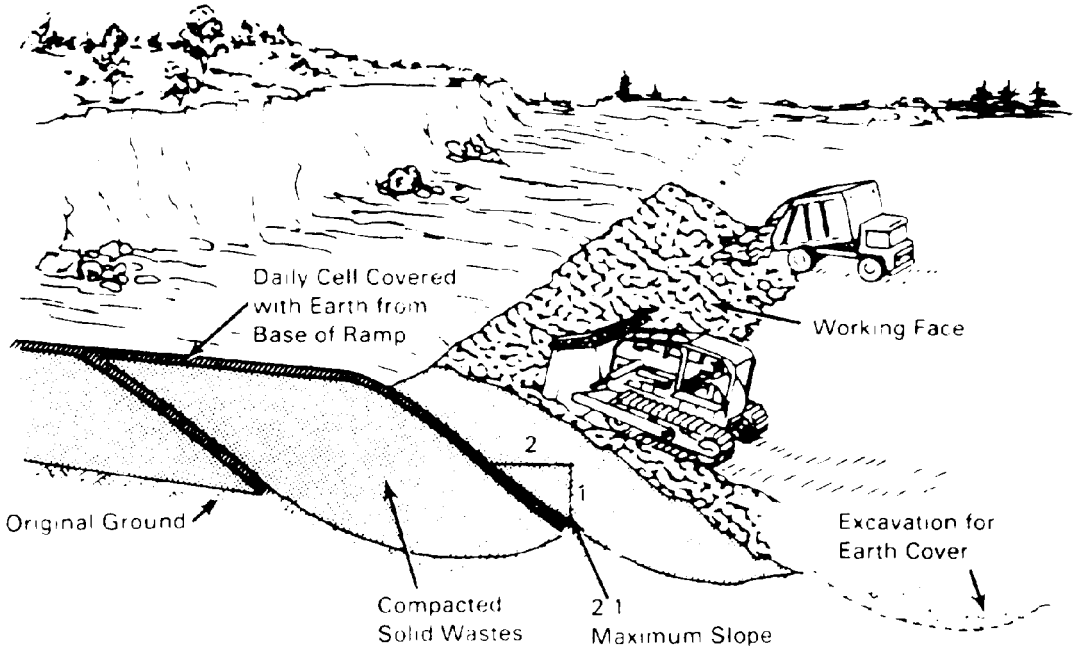


FIGURE 4-2-7B
Ramp Method of Operation for a Sanitary Landfill

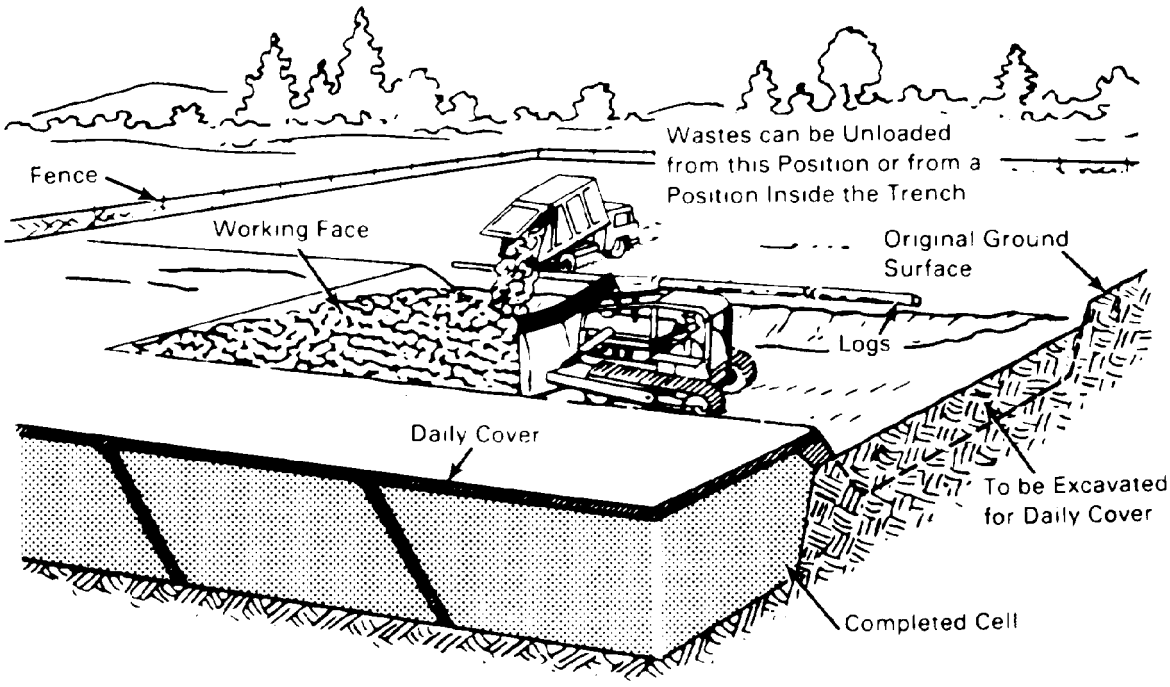


FIGURE 4-2-7C
Trench Method of Operation for a Sanitary Landfill

4.2.7.8 If a canyon floor is reasonably flat, the first fill in a canyon site may be carried out using the trench method operation discussed previously. Once filling in the flat area has been completed, filling starts at the head end of the canyon and ends at the mouth. An important consideration is that since the canyons and ravines are formed by water erosion, landfilling may involve a water course. This practice prevents the accumulation of water behind the landfill. Wastes usually are deposited on the canyon floor and from there are pushed up against the canyon face at a slope of about 2 to 1. In this way, a high degree of compaction can be achieved. Compacted densities as high as 1200 lb/yd^3 have been reported. Even higher densities have been recorded in the lower portions of the landfill as the height of the fill increases.

4.2.7.9 Pit and quarry landfill sites are always lower than the surrounding terrain, so control of surface drainage is often the critical factor in the development of such sites. Also, borrow pits and quarries usually do not have adequate soil or geological properties for landfilling because they display high permeability and fracturing. As with canyon sites, pit and quarry sites are filled in multiple lifts, and the method of operation is essentially the same. A key to the successful use of pits or quarries is the availability of adequate cover material to cover the individual lifts as they are completed and to provide a final cover over the entire landfill when the final height is reached. Because of settlement, it is usually desirable to fill pit and quarry sites to a level slightly above that of the surrounding terrain. The depression method is also not readily amenable to liners and leachate collection system.

4.2.7.10 *Evaluation of Seepage Potential* (Tchobanoglous, Theisen, and Eliassen 1977). Core samples must be obtained to evaluate the seepage potential of a site that is being considered for a landfill. Sufficient borings should be made so that the stratigraphic formations under the proposed site can be established from the surface to (and including) the upper portions of the bedrock or other confining layers. At the same time, the depth to the surface water table should be determined along with the piezometric water levels in any bedrock or confined aquifers that may be found.

4.2.7.11 The resulting information is then used to (1) determine the general direction of groundwater movement under the site, (2) determine whether any unconsolidated or bedrock aquifers are in direct hydraulic connection with the landfill, and (3) estimate the vertical seepage that might occur under the landfill site.

4.2.7.12 *Drainage and Seepage Control Facilities.* In addition to the seepage analysis , it is also necessary to develop an overall drainage plan for the area that shows the location of storm drains, culverts, ditches, and subsurface drains as the filling operation proceeds. In some cases it may also be necessary to install seepage control facilities.

4.2.7.13 To ensure the rapid removal of rainfall from the completed landfill and to avoid the formation of puddles, the final cover should have a slope of about 1%. Where relatively impervious cover material such as clay is used, lesser slope values may be feasible. The theoretical amount of water that could enter the landfill per unit area in a 24-h period for various cover

materials is given in Table 4-2-7A, assuming that (1) the cover material is saturated, (2)a thin layer of water is maintained on the surface, and (3) there is no resistance to flow below the cover layer.

TABLE 4-2-7A
Theoretical Volume of Water that Could Enter Completed Landfill Through 1 ft^2 of Various Cover Materials in 1 Day

Cover Material	Volume of Water, gal
Uniform coarse sand	9970
Uniform medium sand	2490
Clean, well-graded sand and gravel	2490
Uniform fine sand	100
Well-graded silty sand and gravel	9.7
Silty sand	2.2
Uniform silt	1.2
Sandy clay	0.12
Silty clay	0.022
Clay (30% to 50% clay sizes)	0.0022
Colloidal clay	0.000022

4.2.7.14 Clearly, these data are only theoretical values, but they can be used in assessing the worst possible situation. In actual practice, the amount of water entering the landfill will depend on local hydrological conditions, the characteristics of the cover material, the final slope of the cover, and whether vegetation has been planted.

4.2.7.15 Among the methods to control the seepage into and out of landfills are (1) the use of impermeable cover materials, (2) the interception of high groundwater before it reaches the fill, (3) equalization of the water levels within and outside the landfill, and (4) the use of an impervious layer of clay material or other sealants.

4.2.7.16 **Conventional Methods for Wet Areas**. Recently, because of concern over the possibility of groundwater contamination by leachate and gases from landfills and the development of odors, the direct filling of wet areas is no longer considered acceptable. Installation personnel need to consult with the state agency before considering disposal in wet areas because it may be illegal. If wet areas are to be used as landfill sites, special provisions must be made to contain or eliminate the movement of leachate and gases from completed cells. Usually this is accomplished by first draining the site and then lining the bottom with a clay liner or other appropriate sealants. If a clay liner is used, it is important to continue operation of the drainage facility until the site is filled in order to avoid the creation of uplift pressures that could cause the liner to rupture from heaving.

4.2.7.17 **Equipment**

4.2.7.18 A wide variety of equipment is available from which to select the proper type and size needed for an efficient operation. The size, type, and amount of equipment required at a sanitary landfill depends largely

on the size and method of operation and, to some degree, on the experience and preference of the operators (Tables 4-2-7B and 4-2-7C). The most common equipment used on sanitary landfills is the crawler tractor, which can be used with a dozer blade, trash blade, or front-end loader. A tractor is versatile and can normally perform all required operations: spreading, compacting, covering, trenching, and hauling the cover material. If a machine is required nearly full time for compaction, it is economically advisable to purchase a landfill compactor. Other types of equipment commonly used at large sanitary landfills, where specialized equipment increases overall efficiency, are scrapers, draglines, graders, rubber-tired loaders, and water trucks. Rubber-tired tractors are recommended for certain landfill operations. Use of this type of equipment, however, leads to a continuous tire maintenance problem and increased equipment downtime. Sketches of a crawler tractor, steel-wheeled tractors, and self-loading scraper are shown in Figures 4-2-7D, E, and F, respectively. Vehicles will have Roll Over Protection/Fall Protection without regard to age of vehicle. (29 CFR 1926.1000.)

4.2.7.19 These types of equipment are designed to perform the following major functions:

1. Waste Handling. This function includes the moving, spreading, and compaction of the waste.

2. Cover Material Handling. Cover material handling includes the excavation, transportation, distribution, and compaction of the cover material.

3. Support Functions. Support functions include the construction and maintenance of the access roads, the control of dust, and protection against fires.

4.2.7.20 Sanitary landfills that handle about 150 tons (136 metric tons), or less, of solid waste per day can normally operate efficiently with one piece of equipment; but provisions must be made for standby equipment. Large landfills that handle more than 300 tons (272 metric tons) of solid waste per day will require more than one piece of equipment. At these sites, specialized equipment can be utilized to increase efficiency and minimize costs.

4.2.7.21 Closure Plans

4.2.7.22 Site closure can be both expensive and difficult if it is not included as part of the initial landfill design.

4.2.7.23 Three basic goals need to be achieved. First, closure shall minimize the need for further maintenance at the landfill site. Second, closure shall place the landfill in a condition that will have the least possible detrimental environmental impacts in the future. Third, the closure plan should consider preparation of the site for future use.

TABLE 4-2-lB

Average Equipment Requirements

	Equipment			
Daily Tonnage	No.	Type	Size	Accessory(1)
0 to 41.7 metric tons	1	Crawler or rubber-tired tractor (0 to 46 tons)	4536 to 13,608 kg (10,000 to 30,000 lb)	Dozer blade Landf ill blade Front-end loader (0.9- to 1.8-rn) (1— to 2-yd)
41.7 to 140.6 metric tons (46 to 155 tons)	1	Crawler or rubber-tired tractor (30,000to	13,608 to 27,216 kg Front-end loader 60,000 lb)	Dozer blade Landfill blade (1.8- to 3.7-rn) (2- to 4-yd)
	(1)	Steel-wheeled		Multipurpose bucket
		compactor Scraper Dragline Water truck		
140.6 to 281.2 metric tons (155 to 310 tons)	1 to 2	Crawler or rubber-tired tractor	13,608 kg (30,000 lb) or more	Dozer blade Front-end loader (1.8— to 4.6-rn) (2- to 5-yd)
	(1)	Steel-wheeled		Multipurpose bucket
		compactor Scraper Dragline Water truck		
281.2 metric tons (310 tons) or more	2 or more	Steel-wheeled compactor	11,690 kg (39,000 lb) or more	Dozer blade Landfill blade Front-end loader
	(1)	Scraper Dragline Road grader Water truck		

(1) Specialized equipment that can improve operation efficiency.

TABLE 4-2-7C
Equipment Selection Guidance for Multiple Unit Sites
(from Eldredge 1974)

Equipment Function	Equipment									
	Loader	Dozer	Compactor	Scraper	Track	Rubber	Dragline	Backhoe	Truck	Motor Grader
Spread Refuse	A	A	A		0	0	0	0	0	0
Compact Refuse	A	A	A		0	0	0	0	0	0
Excavate Cover	A	A	0		A(1)	A(1)	A	A	0	0
Haul Cover										
91 m (300 ft) or less	A	A	B		A	0	C	C	C	0
91 m-305 m (300 ft-1000 ft)	C	0	0		A	B	C	C	C	0
More than 305 m (1000 ft)	C	0	0		0	A	C	C	C	0
Spread Cover	A	A	A		B	B	0	0	0	B
Compact Cover	A	A	A		0	0	0	0	0	0
Shape Cover	B	B	B		B	B	0	0	0	A

A = Excellent choice
B = Secondary choice
C = "In-Combination Only" choice
0 = Not applicable or poor choice
(1) = Scrapers may require loading assistance in tough soils and adverse weather conditions

Courtesy of Eldredge, R. W., "Selection of Sanitary Landfill Equipment," Waste Age, January/February, 1974.

FIGURE 4-2-7D
Crawler Tractor

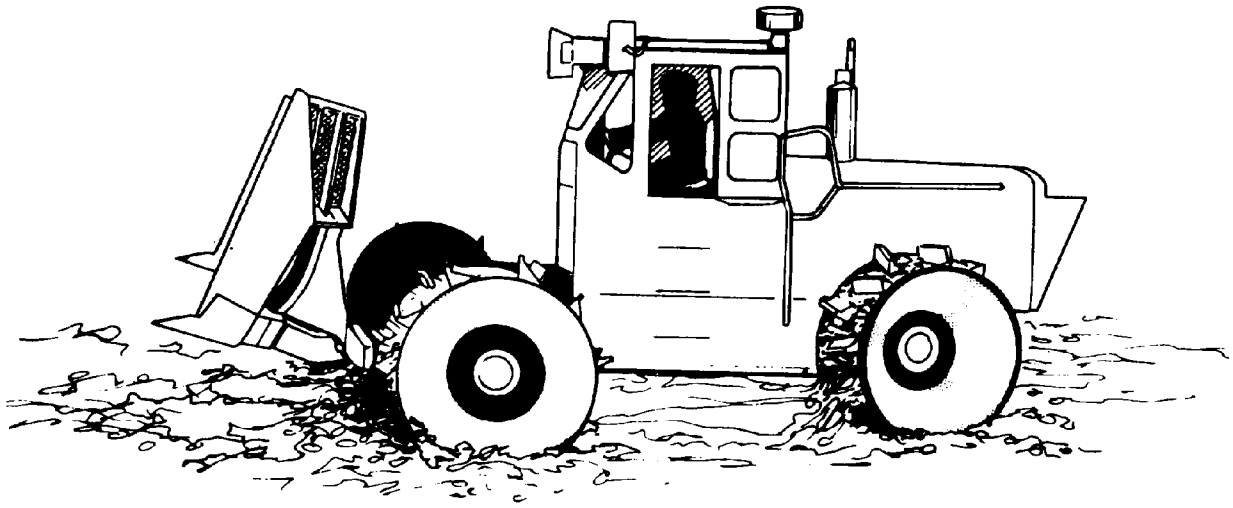


FIGURE 4-2-7E
Steel-Wheeled Compactor

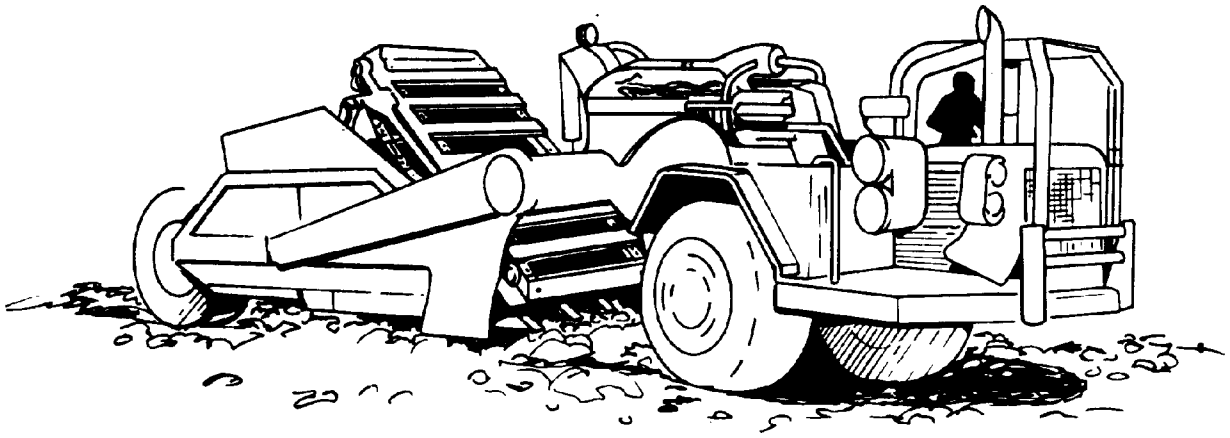


FIGURE 4-2-7F
Self-Loading Scraper

4.2.7.24 Table 4-2-7D (Robinson 1986) identifies tasks that must be accomplished during site closure. Some regulatory agencies are requiring that the developer prepare a closure plan as part of the initial plans for the landfill. If a closure plan has not been developed, the tasks identified in the table under “Preplanning” must be completed. Preplanning includes specifying the final topographical contours for the landfill and establishing procedures for storm water removal.

4.2.7.25 A source of cover shall be identified when the fill is designed. If additional cover material will be needed, it shall be brought to the site while the landfill is operating. This will ensure that cover is available when the landfill is closed, and the cost can be recovered from current landfill users. Another preplanning element is preparing a landscaping and vegetative cover plan for implementation upon closure. This is in addition to planning other features of the landfill such as gas vents, leachate collection facilities, or groundwater monitoring systems. A schematic of a closed landfill is shown in Figure 4-2-7G. Impermeable membranes are used to control movement of landfill gases and leachate.

TABLE 4-2-7D
Site Closure Checklist

Preplanning

Identify final site topographic plan.
Prepare site drainage plan.
Specify source of cover material.
Prepare vegetative cover and landscaping plan.
Identify closing sequence for phase operations.
Specify engineering procedures for the development of onsite structures.
Annotate base maps showing landfill area, time period, and source for further details.

Six Months Before Closure

Review closure plan for completeness.
Schedule closing date.
Prepare final timetable for closure procedures.
Notify appropriate regulatory agency.
Notify site users by letter if they are municipalities or contract haulers, and by published announcement if private dumping is allowed.

At Closure

Erect fences or appropriate structures to limit access.
Post signs indicating site closure and alternative disposal sites.
Collect any litter or debris and place in final cell for covering.
Place cover over any exposed refuse.

Three Months After Closure

Complete needed drainage control features or structures.
Complete, as required, gas collection or venting system, leachate containment facilities, and gas or groundwater monitoring devices.
Install settlement plates of other devices for detecting subsidence.
Place required thickness of earth cover over landfill.
Establish vegetative cover.

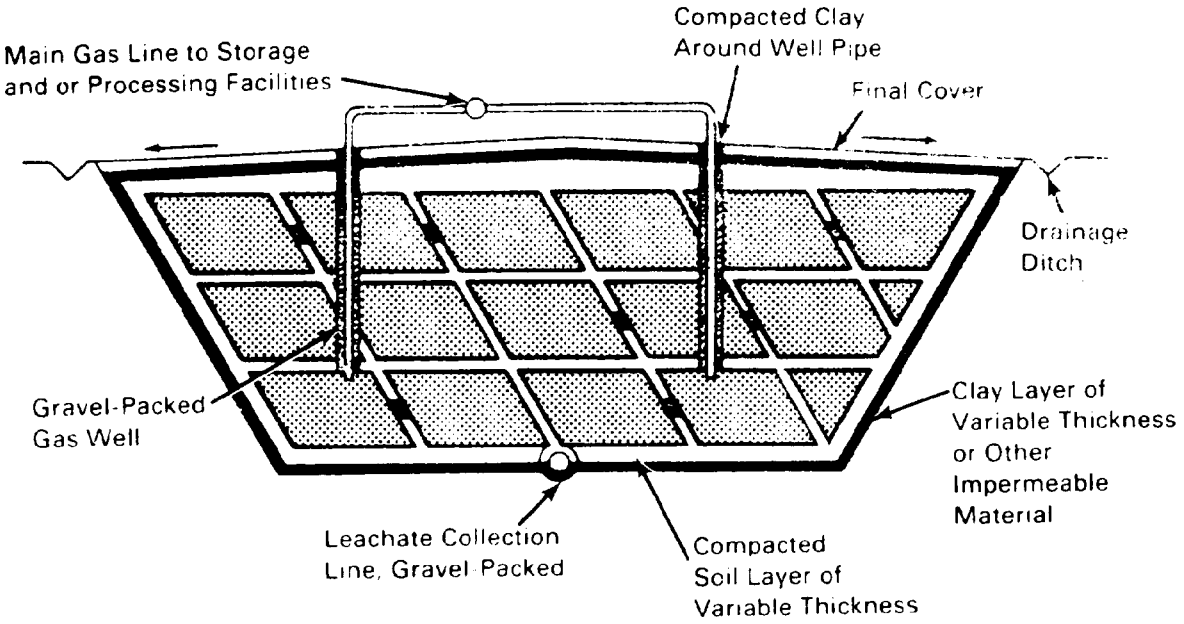


FIGURE 4-2-7G
Use of Impermeable Liners to Control Movement of Gas and Leachate

4.2.7.26 The long-term maintenance of a closed landfill site will be a function of the ultimate site use. Many current landfills have gas and leachate collection systems that will require continuous attention after closure. Groundwater monitoring devices may also be incorporated into the design to check the performance of the leachate control system. Other site features that will require a degree of attention on a continuing basis are drainage control structures and erosion control features.

4.2.7.27 Methane gas control systems may be either active or passive. Passive systems allow the gas to escape to the atmosphere by natural means. The blower and pumps in the active system require periodic maintenance. In addition, the withdrawal pipes and collection lines may need condensate removed and repairs of damage caused by differential settling.

4.2.7.28 Leachate collection systems installed at landfills will require continuous attention once the landfill is closed. The leachate collection system must be maintained to ensure effective operation. This work may include annual leachate collection pipe cleaning, collection tank cleaning, and inspection and pump cleaning and repairs. Collected leachate needs to be disposed of in the appropriate manner. Failure to withdraw leachate could allow it to seep out of the side of the landfill and possibly contaminate groundwater. Records shall be maintained that show the quantity of leachate removed. The leachate quantity will vary with the season of the year and shall be carefully monitored, possibly with automated signaling devices to ensure that it is being properly removed. The duration over which this must be practiced is somewhat uncertain. Regulations require that many

landfills have a groundwater monitoring system incorporated into their design. The purpose of these wells is to evaluate the performance and design of the facilities provided for leachate control.

4.2.7.29 Drainage control problems can result in accelerated erosion of a particular area within the landfill. Differential settling of drainage control structures can limit their usefulness and may result in failure to direct storm water properly off the site. Serious erosion problems can result from improper drainage control.

4.2.7.30 The site closure plan should consider that sites larger than 10 acres be prepared for the DoD forestry program if no more productive use is planned. Production of species with shallow root systems, such as Virginia pines or cedar, for Christmas trees may be a viable alternative.

4.2.7.31 The criteria for Solid Waste Disposal Facilities are currently undergoing revision by the EPA. The proposed (1988) revisions are included in Appendix A-I.

4.2.8 Volume Reduction

4.2.8.1 Reducing the volume of solid waste has the potential for cost savings when land costs are high or space is unavailable, or transfer and long-distance hauling are necessary. Several processes are available for consideration. All are expensive and shall be justified only when significant cost savings can be achieved in the disposal process. Table 4-2-8A summarizes advantages of common waste processing techniques. Resource recovery is discussed in Section 4.3. Incineration is the topic of Section 4.4.

4.2.8.2 Mechanical volume reduction by compaction is widely practiced. Shredding is less common because component wear (cost) is high. Table 4-2-8B lists several types of commercially available compaction equipment. Table 4-2-8C gives important design factors to consider in the selection of compaction equipment.

4.3 RESOURCE RECOVERY AND RECYCLING

4.3.1 *Resource Conservation.* Resource conservation is defined as the reduction of the amounts of solid waste that are generated, reduction of overall resources consumed, and utilization of recovered resources. DoD policy is that solid and other waste materials will be reduced at the source whenever possible.

4.3.2 *Reuse/Recycling.* Reuse is defined as the use of a waste material or product more than once without any change in form. For example, a soft-drink bottle is reused when it is returned to a bottling company and refilled. Recycling is the process by which reclaimed resources are transformed into new products in such a manner that the original products may lose their original forms. A market analysis is essential before instituting recycling programs. The material must be in a form that the market will accept (i.e., clean, segregated, etc.). For example, an aluminum can is recycled when it is returned to the smelter, melted, and reformed into sheet aluminum to be manufactured into a new can or another completely different product. The

TABLE 4-2-8A
Solid Waste Processing Methods

Processing Method	Description	Advantages	Disadvantages
Baling (mechanical volume reduction)	Compresses various raw solid wastes into uniform shapes	Extends life of land disposal site Can handle variety of solid wastes Bulk reduction makes long hauls more economic Bales are more convenient for rail hauling Minimal land settling and gas generation compared with other sanitary landfills Corrugated containers and paper can be baled for sale Potential for 50% volume reduction	High initial investment per ton Precludes resource recovery after bale is formed
Shredding (mechanical size reduction)	Breaks up wastes through crushing, grinding, chipping, or tearing (Reciprocating blades only. Hammermills are not to be used on military installations.)	Handles most types of wastes Significant volume reduction (25-60%) Ferrous metal can be recovered for recycling via magnetic separation	Not useful on large or high moisture wastes Component wear is high Explosive materials are a hazard when processed by the shredder Dust and debris discharge is high
Component Separation (Resource Recovery, see Section 4.3.1)	Manual or mechanical removal of salable materials from the waste stream	Recovers valuable resources Generates income Reduces ultimate refuse weight and volume	Labor intensive (even with mechanical systems) Requires local market for most recovered materials in order to be economic
Incineration (Chemical Volume Reduction, see Section 4.3.2)	Controlled burning of solid, liquid, or gaseous waste	Weight reduction of 60-70% is practical. Volume reduction of 80-90% achieved on most municipal wastes Adaptable to energy recovery processes such as steam generation Some waste products can be salvaged after incineration	Large capital expenditures High operating costs Requires skilled labor for operation Improper operation can result in air, water, and land pollution Cannot handle bulky, slow combustion, or high temperature burning materials

TABLE 4-2-8B
Compaction Equipment Used for Volume Reduction

Location or Operation	Type of Compactor	Remarks
Solid waste generation points	Stationary/residential	
	Vertical	Vertical compaction ram; may be mechanically or hydraulically operated; usually hand-fed; wastes compacted into corrugated box containers or paper or plastic bags; used in medium- and high-rise apartments.
	Rotary	Ram mechanism used to compact wastes into paper or plastic bags on rotating platform, platform rotates as containers are filled; used in medium- and high-rise apartments.
	Bag or extruder	Compactor can be chute-fed; either vertical or horizontal rams; single or continuous multibags; single bags must be replaced and continuous bags must be tied off and replaced; used in medium- and high-rise apartments.
	Undercounter	Small compactors used in individual residences and apartment units; wastes compacted into special paper bags; after wastes are dropped through a panel door into bag and door is closed, they are sprayed for odor control; button is pushed to activate compaction mechanism.
	Stationary/commercial	Compactor with vertical or horizontal ram; waste compressed into steel container; compressed wastes are manually tied and removed; used in low-, medium-, and high-rise apartments, commercial and industrial facilities.
Collection	Stationary/packer	Collection vehicles equipped with compaction mechanisms
Transfer and/or processing station	Stationary/transfer trailer	Transport trailer, usually enclosed, equipped with self-contained compaction mechanism.
	Stationary	
	Low pressure	Wastes are compacted into large containers.
	High pressure	Wastes are compacted into dense bales or other forms.
Disposal site	Movable wheeled or tracked equipment	Specially designed equipment to achieve maximum compaction of wastes.
	Stationary/track-mounted	High-pressure movable stationary compactors used for volume reduction at disposal sites.

TABLE 4-2-8C
Important Design Factors in the Selection of Conventional Compaction Equipment

Factor	Value		Remarks
	Unit	Range	
Size of loading chamber	yd^3	< 1-11	Fixes the maximum size of wastes that can be placed in the unit.
Cycle time	s	20-60	The time required for the face of the compaction ram, starting in the fully retracted position, to pack wastes in the loading chamber into the receiving container and return to the starting position.
Machine volume displacement	yd^3/h	30-1500	The volume of wastes that can be displaced by the ram in 1 h.
Compaction pressure	$lb/in.^2$	15-50	The pressure on the face of the ram.
Ram penetration	in.	4-26	The distance that the compaction ram penetrates into the receiving container during the compaction cycle. The further the distance, the less chance there is for wastes to fall back into the charging chamber and the greater the degree of compaction that can be achieved.
Compaction ratio		2:1-8:1	The initial volume divided by the final volume after compaction. Ratio varies significantly with waste composition.
Physical dimensions of unit	variable	variable	Affects the design of service areas in new building and provision of service to existing facilities.

Note: yd3 x 0.7646 m 3 ^{3}
yd3/h x 0.7646 = m^3/h
$lb/in.^2$ x 0.0703 = kg/cm^2
in. x 2.54 = cm

recycling of used oils and solvents is discussed in Section 4.4. The military specification (MIL-F-2495) that allows the reclamation of used oils and solvents is given in Table 4-3-2A. Both of these methods are resource conservation measures because the original products do not enter the waste stream and require disposal.

TABLE 4-3-2A
Specifications for Fuel Oil Reclaimed (MIL-F-2495)

Characteristics	Requirements	FED-STD 791 Test Method	ASTM Test Method
API Gravity @ 60°F (hydrometer range)	25-40		0 287
Viscosity at 1O4°F (40°C) range Kinematic Viscosity, cts	2.0-15.0		D 445
Viscosity @ 122°F (50°C) range Saybolt Universal Seconds	30-90		0 88
Flash Point (mm.)	130°F/55°C		D 93
Pour Point (max.)	20°F/-6.7°c		D 97
Sulfated Ash, Percent (max.)	0.15		D 874
Water & Sediment, Percent (max.)	2.0		D 1796
Neutrality	Neutral	5101	
Sediment Percent (max.)	0.5		0 473
Chlorinated Material 1.1)	No Green Flame		
Sulfur Content, Percent (max.)	2.0		D 129(2)
Explosiveness, Percent (max.)	50	1151.1	

(1) FOR (Fuel Oil Reclaimed) shall be essentially free of chlorinated material. To determine the presence of chlorinated material, a clean copper wire is heated in a clear blue gas flame (to red heat) until no green shows in the flame. The wire is dipped while still hot (into a sample of FOR) and then put back into the flame. No green shall show in the flame. (For practice, a blend of 1% trichloroethane in DFM or other distillate fuel *may* be used as a sample of an oil that fails this test. The oil should be purged of any sodium chloride by washing with fresh water.)

(2) (Or other approved ASTM method.) In the United States, sulfur limits shall be as specified by the EPA, state, or community where the fuel is to be used, whichever is more restrictive. In foreign countries, the sulfur limit shall conform to the limit established in the Status of Forces Agreement.

4.3.3 *Material Conservation.* Another method of resource conservation is to reduce the amount of material used to make certain products. Normally, this will have very little effect on military installations. However, there are three ways in which material conservation can be encouraged on military installations. (1) Encourage purchase of materials with a minimum amount of packaging. Many times the packaging in a shipment is larger or heavier than

the material it protects. This is unavoidable in the shipment of delicate instruments, computer components, etc; however, many times durable goods are shipped in the same manner. (2) Shipping and packaging specifications shall be written in order to avoid use of excess packaging. Military procuring agencies shall inventory shipping and packaging policies to determine if unnecessary packaging is being used or required. (3) Reuse of cartons and packaging materials may also be encouraged in some instances.

4.3.4 *Use of Recycled Materials.* The Resource Conservation and Recovery Act (PL 94-580) requires federal procuring agencies to "procure items composed of the highest percentage of recovered materials practicable consistent with maintaining a satisfactory level of competition." [Section 6002(c)(1)(a)]. This requirement applies to items with a purchase price in excess of $10,000 or where a quantity of items purchased in the preceding fiscal year was $10,000 or more [Section 6002(a), RCRA]. These policies have resulted in federal agencies being required to evaluate their procurement regulations and have helped create a market for recycled, and therefore recyclable, materials. Procurement of materials in such a manner to minimize the generation of wastes is required.

4.3.4.1 Careful planning by procurement agencies to order items containing recycled materials will result in their being ordered in large quantities. This practice will result in reduced per unit costs. Some items that regularly contain recycled materials and which are ordered by most federal purchasing agencies are paper products (especially office paper, packaging, paper towels, and bathroom tissue) and certain types of metals, plastics, and fabrics. Re-refined oil may also be purchased in bulk quantities by procurement agencies. Where it has been shown to be more economical than burning used oil in heating plants, make every effort to enter into a program in which waste oil generated by the installation may be sold to a re-refiner and re-refined oil purchased for a reduced price. Current military specifications allow for the use of re-refined oil in administrative vehicles. As these specifications are expanded to include tactical vehicles, procurement agencies shall in turn eliminate specifications requiring the purchase of virgin petroleum products and preventing the purchase of re-refined products.

4.3.5 *Minimize Waste.* Commanders shall ensure that waste of military items and property is prevented. One way is to conduct a survey to determine waste generated by shops and other facilities. The items found by the survey shall be evaluated to determine if waste could be minimized by substitution of materials, change of process, or elimination of material or process. Every effort shall be made to procure items so that the items or components of the items can be converted to other users when no longer suitable for their original use. Some examples of waste reduction applicable to military installations are:

- use of refillable beverage containers
- use of reusable food service plates, cups, and utensils
- use of both sides of paper in printing reports and documents
- use of recyclable packaging containers for procurements.

4.3.5.1 Military agencies shall make every effort to prevent overissue of expendable items. Procurement agencies shall make every effort

to ensure that the product ordered is the product actually required to accomplish the task. Using the product for which it was designed will help to extend its functional lifetime.

4.3.6 Recovery of Resources

4.3.6.1 **Why Establish a Resource Recovery and Recycling Program?** The Military Construction Codification Act (PL 97-214) became effective 1 October 1982. The provisions of this Act expanded the scope of recyclable materials and provided increased incentives for implementing recycling programs. Under appropriate departmental guidance, generators of recyclable materials can establish Qualifying Recycling Programs (QRP). Expenses of operating and improving recycling programs must be accumulated and reimbursed from proceeds of sales of recyclable materials prior to any other disposition of the proceeds.

4.3.6.2 Projects such as those described in Section 2577(b)(2) of the Act are not to be included in the normal military construction program if sufficient recycling program proceeds are available at the installations needing the projects. Accumulation of proceeds from sales of recyclable materials is authorized only for installations with qualifying recycling programs. The proceeds from the sale of recyclable materials must be deposited into **F3875 "Budget clearing account (suspense)" and segregated within that account to ensure proper accounting as to the amounts collected and their disposition. The accumulation of funds in **F3875 is not affected by fiscal year end, so proceeds acquired during one fiscal year may be carried forward and merged with proceeds of subsequent fiscal years. Reimbursements to operation and maintenance accounts to cover the expenses of recycling programs shall be made from **F3875 as needed within a fiscal year. Funds remaining in **F3875 after reimbursement of expenses may be used only for projects and activities as described in Section 2577(b)(2) or may be disbursed to the morale and welfare account of the installation pursuant to Section 2577(b)(3) or both. If the balance of an installation’s proceeds remaining in **F3875 exceeds $2,000,000 at the end of each fiscal year, the amount in excess of $2,000,000 must be deposited into the U.S. Treasury as miscellaneous receipts.

4.3.6.3 Successful recycling programs exist at many military installations. For example, for FY 87, four installations reported proceeds in excess of $500,000. Additionally, 19 other activities reported proceeds in excess of $100,000 for the same year.

4.3.6.4 Paper goods, including cardboard, are the materials most often recycled. At support or construction activities scrap metal and sometimes scrap wood are important sources of income for recycling programs. Recycling aluminum cans is best in areas where aluminum is produced. Otherwise transportation costs significantly decrease net income to the base.

4.3.7 Development of Resource Recovery and Recycling Program. A Resource Recovery and Recycling Program (RRRP) must be developed systematically and be justified economically. The main steps involved in establishing a new program are shown in Figure 4-3-7A.

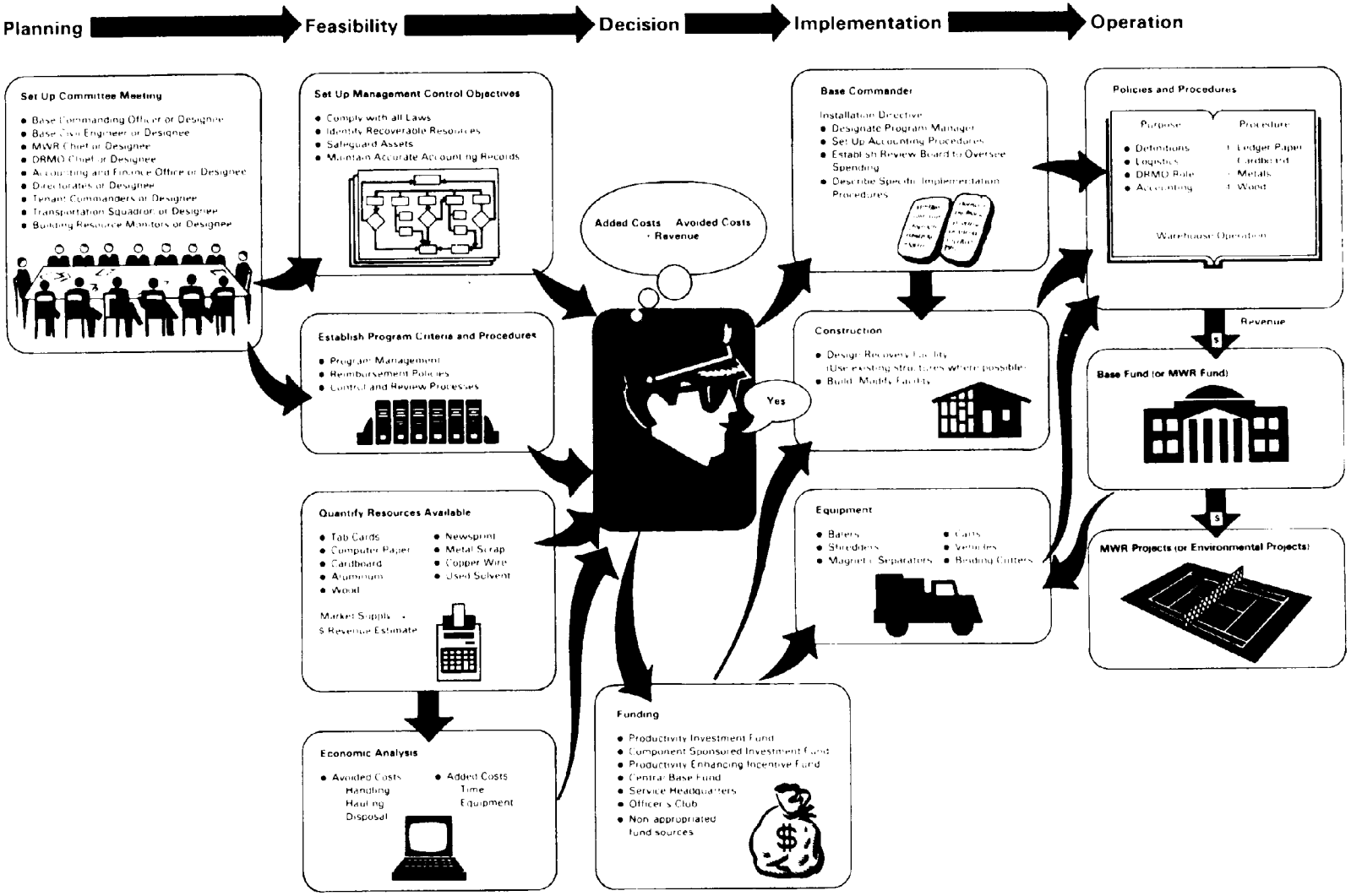


FIGURE 4-3-7A
Establishing a New RRRP

4.3.7.1 **Program Initial Steps**

4.3.7.2 A successful program requires an advocate who is willing to follow its development from conception to finalization. That person could be anyone from a civilian employee to the base commander.

4.3.7.3 The advocate must first start by calling together people who will eventually be involved in actual operation of. the program. Suggested participants are the Chief of Morale, Welfare, and Recreation (MWR), the Chief Civil Engineer, a representative from DRMO, a representative from fire and safety, and the base financial officer. The meeting should focus on procedures for actually setting up a QRP.

4.3.7.4 **Identification of Recyclable Materials.** Commanders and commanding officers of military installations are encouraged to strongly support the base RRRP. While industrial fund installations may be conducting individual programs to sell scrap generated in their operations, they may contribute to the installation program any materials that do not qualify for inclusion in their sales programs or any scrap that they cannot sell economically.

4.3.7.5 *Recyclable Materials.* Materials qualifying for sale under the program are materials that normally have been or would be discarded (i.e., scrap and waste) and that may be reused after undergoing some type of physical or chemical processing. Unless specifically excluded, any material that meets this definition may be sold under this program. Table 4-3-7A is an excerpt from program guidance listing some potentially recyclable materials. The definition of recyclable materials SPECIFICALLY EXCLUDES the following materials:

1. Precious-metal-bearing scrap.

2. Items that may be used again for their original purposes or functions without any special processing, e.g., used vehicles, vehicle or machine parts, bottles (not scrap glass), electrical components, unopened containers of unused oil/solvent, furniture, filing cabinets, etc.

3. Ships, planes, weapons, or any discarded material that must undergo demilitarization or mutilation prior to or as a condition of sale.

4.3.7.6 Dollar values fluctuate frequently and may vary significantly from the listed values based on various economic factors. Whether a waste may or may not be cost effectively recycled depends on local conditions. Some areas may not have a market for certain materials, or an installation may not have a large enough generation rate of a particular material to make recycling cost effective. Activities may have to pay for removal of some recyclable materials but could save money through avoided cost for disposal in a landfill or incinerator. Prices listed in the table may vary greatly depending on location and quality of the material. The DRMD market analysis shall identify which wastes are marketable in any areas.

4.3.7.7 The quality of the waste material also plays a major role in determining its value. DRMO will not segregate materials for an

TABLE 4-3-7A

Potentially Recyclable Materials

Material	Value[1]	Comments
Tab cards	$47-210/net ton	If cards are colored, values drop.
Computer paper	$50-200/net ton	Cannot contain carbon or staples.
Cardboard	$5-45/net ton	Must have efficient baler to be feasible.
Aluminum	$0.12-0.40/lb	Includes aluminum cans. Value increases if aluminum is clean and does not contain iron.
Rubber	$0.01-0.05/lb	Does not include usable tires.
Glass cullet	$0.01-0.02/lb	Markets are scarce.
Used oil	$0.10-0.40/gal	May fall under reutilization Program. (2)
Used solvents	$0.l0-0.36/ gal	As permitted by Used Solvent Elimination Programs
Newsprint	$4-15/net ton	Although it is rare, values of $151/net ton have been obtained.
Metal scrap (light)	$10-67/gross ton	
Metal scrap (heavy)	$45-70/gross ton	
Copper wire (bare)	$0.25-0.50/lb	
Copper wire (insulated)	$0.20-0.22/lb	
Scrap wood	$0.01-0.10/lb	
Hydraulic fluid	$0.22-0.50/gal	
Used coolants	$0.45-0.50/gal	
Items which have exceeded shelf-life		Some require chemical or physical (i.e., recontainerization) processing
Acids		
Bases		
Cooking grease, bones and fat	$0.02-0.16/lb $0.04-0.09/lb	

(1) All values were obtained during a September 1984 survey.
(2) Commands are authorized to sell contaminated fuels or waste oils through DRMO only after it has been determined that the material is excess of the military's needs.

but they will advise on the degree of segregation necessary for the most cost-effective operation. Quality control of source separation techniques is essential. For example, when recycling mixed paper, it is important that employees do not throw paper clips, carbons, and other trash into collection boxes.

4.3.7.8 Table 4-3-7B shows how detailed the price structure breakdown can be for paperstock materials. The table also illustrates that prices will vary depending on markets. The end consumers for many recycled goods on the West Coast are the Pacific Rim countries. This market is just developing now, but future growth looks good.

4.3.7.9 Packaging is also important; for example, because of bulk storage and transportation problems, cardboard cannot be economically recycled unless it is baled. Some materials also need to be packaged according to certain specifications.

4.3.7.10 Remember, if the item needs to be chemically or physically processed before reuse, then it is properly defined as a recyclable item. As examples, for expired shelf-life items, recontainerization is physical processing; chemical processing could mean increasing the concentration of a chemical that has become insufficient to do the job [calcium hypochlorite with a chlorine level that has dropped from 17% (MILSPEC levels) to 10% could be reblended with chlorine to bring up the chlorine content].

4.3.7.11 Plastics recycling is not yet widely practiced at military installations. Concern over pollution caused by plastics during incineration and environmental concerns about longevity in landfills may force increased activity in that area.

4.3.7.12 In the commercial sector plastics recycling is beginning to increase (Basta and MacKerron 1988; Crawford 1988). Potential end uses include decorative beams, railroad ties, and other shapes for landscaping. Shredding plastics and using them as fiberfill is another end use.

4.3.7.13 Preparing Criteria and Procedures. General criteria and procedures for establishing a recycling program are summarized below but must be adapted to fit particular installations.

4.3.7.14 *Program Criteria.* A qualifying recycling program is defined as an organized operation that requires concerted efforts to divert or recover scrap or waste from waste streams, as well as efforts to identify, segregate, and maintain or enhance the marketability of the materials.

4.3.7.15 A prerequisite for setting up an installation program is to ascertain that the program is both feasible and cost effective by identifying potentially recyclable materials, estimating generation rates, determining if adequate markets exist, and conducting an economic analysis for each material. (Details of the economic analysis are given later in this section.)

4.3.7.16 An installation program must be formally established with provisions for program management, reimbursement for program expenses, administration, accounting, and proper control and review of projects to be funded.

TABLE 4-3-78
Paperstock Markets and Prices[1]
(Nominal Prices in $/Ton, Feb. 1988)

Paper Types	New York	Chicago	Atlanta	West Coast
Hard white envelope cuttings	250-260	275-285	285-295	265-275
Hard white shavings	230-240	240-250	250-260	205-215
New colored envelope cuttings	110-120	105-115	120-130	95-105
Coated soft white shavings	125-135	160-170	160-170	120-130
New brown Kraft envelope cuttings	95-105	100-110	120-130	115-125
White ledger (Manifold)	100-110	110-120	110-120	85-95
White ledger (post consumer)	70-80	30-40	40-50	40-50
New colored ledger (Manifold)	50-60	65-70	30-40	35-45
Colored ledger (post consumer)	20-25	20-30	30-40	10-15
White newsblanks	100-110	105-115	115-125	95-105
Coated sulphite books	40-50	35-45	45-55	45-55
Manila tab cards	200-210	175-185	195-205	195-205
Colored tab cards	135-145	120-130	140-150	115-125
Kraft multi-wall bag waste	105-115	105-115	115-125	145-155
Flyleaf shavings no. 1	30-35	30-35	45-50	50-60
Mixed groundwood shavings (nom.)	10-15	10-15	10-15	30-40
New DLK cuttings	90-100	90-100	95-105	85-95
No. 1 news	20-25	35-40	50-55	30-40
Corrugated containers	25-35	25-35	40-50	20-30
Boxboard cuttings	20-25	25-30	20-30	20-30
Computer printout (laser free)	85-95	85-95	85-95	155-165
Computer printout (laser 10-15%)	65-75	70-80	70-80	110-120
Mixed paper prices (dep. on grade)...nom.	2-5	2-5	2-5	2-5

(1) From Mill Trade Journal, February 29. 1988, pg. 3.

4.3.7.17 *Procedures.* Proceeds from the sale of recyclable materials are deposited into a special account (**F3875). This account is not affected by fiscal year end, so proceeds may be carried forward from one year to the next. However, if the balance of an installation's net proceeds remaining at the end of any fiscal year exceeds $2,000,000, the excess must be deposited into the U.S. Treasury.

4.3.7.18 The proceeds are first applied to cover the costs of operating the program, including the cost of any equipment purchased for recycling purposes.

4.3.7.19 If a balance remains after reimbursement of program expenses, not more than 50% of that balance may be used at the installation for projects for pollution abatement, energy conservation, and occupational safety and health activities. A project funded under the program may not exceed 50% of the amount established by law as the maximum amount for a minor construction project (i.e., the cost of a funded project at this time may not exceed 50% of $200,000, or $100,000).

4.3.7.20 Any part of the balance remaining after reimbursement of program expenses may be transferred to a local nonappropriated fund instrumentality supporting military MWR activities.

4.3.7.21 The Defense Reutilization and Marketing System (DRMS), represented locally by the DRMO, supports the recycling program by

1. conducting market research to provide estimates on proceeds from the sale of materials

2. providing advice on procedures for collecting, segregating, and storing materials to optimize sales proceeds

3. assuming accountability for materials made available for sale

4. determining whether materials turned in under the recycling program shall be diverted to a higher priority program [through the reutilization, transfer, donation, and sale (RTDS) cycle per DoD 4160.21-M)

5. conducting sales and depositing the proceeds to the program account.

4.3.7.22 *Management Control Objectives.* Management control objectives in operating the recycling program are as follows:

- **!** to comply with legal restrictions on uses of funds. The provision for program budgets and prior authorization of expenditures will ensure that funds are used only in compliance with the law.

- **!** to comply with legal limitations on the accumulation of funds and percentages of fund balances that may be used to finance projects. The Base Comptroller will adopt appropriate accounting controls to ensure compliance with these restrictions.

- ! to identify valuable resources now being lost in the waste stream and to divert these resources to the recycling program. The Recycling Planning Board(1) will foster an awareness of the value of resources and investigate the feasibility of recycling materials of any potential value.

- ! to identify recyclable wastes which are currently being disposed of in a landfill, incinerator, or other solid waste management facility and which could be disposed of at a lower cost through recycling or resource recovery.

- ! to safeguard assets, and to the degree warranted by their value, establish custody and access controls on select items collected for recycling. In developing bulletins on specific materials, the Board will consider the value and pilferability of the items and prescribe appropriate controls.

- ! to maintain accurate accounting records. The Base Comptroller will adopt appropriate operating procedures to ensure the accuracy of accounting records.

- ! to use the net proceeds on approved projects that will provide the maximum benefit to the maximum number of people.

4.3.7.23 **Economic Evaluation.** Economic analysis to justify an RRRP may be based on revenues from sale of recyclable materials or cost avoidance for disposal of wastes in a solid waste management facility.

4.3.7.24 Before any recycling activity can be approved, an economic analysis must be performed. Service directives provide details for making such an assessment. Most of the main points are summarized below. The example economic analysis is based on a source separation program. It is also specific to recycling of TAB cards only. The procedure for evaluating other materials would be quite similar.

4.3.7.25 Factors for Economic Analysis and Implementation Schedule Format

1. Determine the approximate quantity of materials that will be source separated, locations where each type of material would be stored for pickup, and frequency of required pickup as influenced by economic, environmental, hygienic, aesthetic, and safety requirements.

2. Request from DRMO a determination of local markets for high-grade paper, corrugated containers, and/or newspapers, as applicable. Information to be obtained from DRMO includes the following:

   - ! market price
   - ! prognosis of price future
   - ! pickup point changes
   - ! any preparation required, such as baling, special tying, etc.

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(1) Described in Section 4.3.12.

3. If there is no market, no further analysis is required.

4. After receiving the market analysis report and the estimated sales revenue from DRMO, the installation conducts an economic analysis to determine if a QRP would be cost effective.

4.3.7.26 **Determining Economic Feasibility.** Selling recyclable material raises revenue, but it may not always be economical. Costs of running the program may exceed savings or revenue. Therefore, do not undertake a QRP without an economic analysis. An economic analysis will help decide the feasibility of establishing a qualifying recycling program.

4.3.7.27 *Economic Analysis Handbook.* Figure 4-3-7B provides a worksheet for documenting an economic analysis. A sample economic analysis is shown in Figure 4-3-7C. For more information on methods for performing economic analyses, see NAVFAC Publication P-442, Economic Analysis Handbook.

4.3.7.28 *Assumptions.* Added costs are the increased time, effort, and possibly equipment associated with removing a recyclable material from the waste stream and subsequently preparing it for sale. Avoided costs are decreases in the costs of waste handling, hauling, and disposal by removing a recyclable material from the waste stream.

4.3.7.29 *Determining Avoided Costs.* Estimate avoided costs by determining the weight or volume of each recyclable material diverted from the waste disposal stream by the QRP. Calculate tipping fees, surcharges, labor, prorated maintenance, hauling fees, permit fees, and generator "taxes" that are saved by recycling that quantity of material instead of disposing of it. This may or may not be a significant factor, depending on the material.

4.3.7.30 *Determining Revenue.* For each recyclable material, estimate annual sales revenue. Use DRMO market survey data for these estimates.

4.3.7.31 *Is a Recycling Program Economically Feasible?* The qualifying recycling program is economically feasible if

added costs < avoided costs + revenue

4.3.8 Qualified Recycling Program (QRP). Upon completion of the economic analysis, the base commander of the installation shall decide whether or not to establish a QRP. Such a decision may be obvious when the added costs are less than or much greater than the avoided costs and revenue. If only a marginal difference exists, however, the decision may be more involved and need consideration of intangible benefits like aesthetics, employee morale, pollution abatement, availability of funds to meet the deficit, and future outlook. Any activity should be able to establish a QRP based on capturing proceeds from recyclable materials already being turned in to the DRMO.

Installation:_____
Preparer:_____
Location:_____ Date:_____
Target recyclable material:_____
Tons-lb-gal/yr:_____

ESTIMATED
ADDED COSTS

1. Source separation and material preparation
   a. Equipment (amortize over life of equipment) $_____/yr
   b. Labor
      (1) Procurement (amortize over life of equipment) $_____/yr
      (2) Operations $_____/yr
      (3) Maintenance $_____/yr
   c. Other (materials, supplies) $_____/yr
   Subtotal: ($_____/yr)
2. Collection and storage
   a. Equipment and facilities (amortize over life of equipment or facility) $_____/yr
   b. Labor
      (1) Procurement (amortize over life of equipment or facility) $_____/yr
      (2) Operations $_____/yr
      (3) Maintenance $_____/yr
   c. Other (materials, supplies) $_____/yr
   Subtotal: ($_____/yr)
3. Program administration
   a. Instructions and operating procedures $_____/yr
   b. Fiscal management $_____/yr
   c. Publicity $_____/yr
   Subtotal: ($_____/yr)
   TOTAL ADDED COSTS: $_____/yr)

ESTIMATED AVOIDED COSTS AND REVENUE

1. Savings resulting from reduced volume of waste going to disposal facilities $_____/yr
2. Sales revenue (tons-lb-gal/yr) x ($/ton-lb-gal) $_____/yr

TOTAL AVOIDED COSTS + REVENUE: $_____/yr

Estimated Return

(Total Avoided Costs + Revenue) - (Total Added Cost) = $_____/yr

FIGURE 4-3-7B
Worksheet for Determining Waste Sales Economic Analysis

Installation: Example
Location: Nowhere, USA
Target Recyclable Material: TAB Cards

Preparer: John Doe
Date: 18 September 1984
Quantity: 200 net tons/yr

ESTIMATED ADDED COSTS

1. Source separation and material preparation		
a. Equipment-none necessary		
b. Labor		
(1) Operations (0.2 manyr/yr)($25,000/manyr)(1.12-overhead)	$ 5,600/yr	
c. Other (Misc. packaging materials)	$ 1,000/yr	
SUBTOTAL		$ 6,600/yr
2. Collection and Storage		
a. Equipment		
(1) Flatbed truck ($25,000)(1 day/wk)/20 yr	$ 250/yr	
(2) Front-end loader ($30,000)(1 day/wk)/20 yr	$ 300/yr	
(3) Warehouse (1300 ft^2)($25.10/$ft^2$)/20 yr	$ 1,631.5/yr	
b. Labor		
(1) Procurement (0.2 manyr)($25,000/manyr)(1.12-overhead)/20 yr	$ 280/yr	
(2) Operations (1 manday/wk)($25,000/manyr)(1.12-overhead)	$ 5,600/yr	
(3) Maintenance (0.1 manyr)($25,000/manyr)(1.12-overhead)	$ 2,800/yr	
c. Other (pallets, shelves, fuel)	$ 2,000/yr	
SUBTOTAL		$12,861.5/yr
3. Program Administration		
a. Instructions and operating procedures (0.1 manyr/yr)($25,000/manyr)(1.12)	$ 2,800/yr	
b. Fiscal management (0.05 manyr/yr)(25,000/manyr)(1.12)	$ 1,400/yr	
c. Publicity (0.05 manyr/yr)($25,000/manyr)(1.12)	$ 1,400/yr	
SUBTOTAL		$ 5,600/yr
TOTAL ADDED COSTS:		$25,061.5/yr

ESTIMATED AVOIDED COSTS AND REVENUE

1. Tipping Fee Savings ($10/ton)(200 tons/yr)	$ 2,000/yr
2. Sales Revenue (200 net tons/yr)($180/net ton) =	$36,000/yr
TOTAL AVOIDED COSTS AND REVENUE:	$38,000/yr

ESTIMATED RETURN

Estimated Return = $38,000/yr - $25,061.5/yr = $12,938.5/yr

FIGURE 4-3-7C
Sample Economic Analysis

4.3.9 Implementation

4.3.9.1 To establish a QRP, the base commander issues an installation directive or instruction identifying the following program requirements:

1. Designate the program manager. Generally, this shall be the department already functionally responsible for the collection and disposal of the waste material.

2. Identify means for maintaining fiscal accountability of funds received and disbursed.

3. Provide for maintenance of records on quantity and types of materials sold for recycling.

4. Provide for review of projects funded with the proceeds of sales. This shall be done by the same people who would review such projects if funded from normal appropriations.

5. Describe specific implementation procedures of the program. Copies of the directive shall be sent to the DRMO and higher Headquarters.

6. Establish procedures for tracking recycling expenses.

4.3.9.2 An installation that does not conduct its own waste disposal program may establish a QRP either by dealing with DRMO or through an agreement with the installation handling its waste disposal. The QRP is to be set up for the entire installation, not separate activities, with the installation as a whole receiving the proceeds from sales. If another installation is handling the waste collection, that installation may or may not be willing to also provide this service for recyclable materials. In any case, in order for a generating installation to be credited directly by DRMO with the proceeds from waste sales, the turn-in document (DD Form 1348-1) must contain a reimbursable fund site specific to that installation. If several generators with QRPs have a centralized collection process and wish to be reimbursed separately, a Form 1348-1 must be submitted for each installation, specifying the amount of material originating from each installation. DRMO will then determine equitable distribution of sales proceeds. A sample DD Form 1348-1 is shown in Appendix G.

4.3.9.3 *Equipment and Facilities*

1. Equipment for establishing of recycling programs shall be procured through the appropriations normally available for equipment acquisition. The acquisition of new or replacement equipment related solely to recycling of solid and other waste is eligible for financing from net proceeds generated by the sale of waste materials. Annual programs for the acquisition of such equipment shall be coordinated with the Office of the Assistant Secretary of Defense for Manpower, Reserve Affairs, and Logistics (MRA&L).

2. The financing of equipment that is used jointly or shared with such activities as the DRMO or Army and Air Force Exchange Service (AAFES)

facility shall be governed by the procedures applicable to the installation that owns or is accountable for the equipment of facility.

3. Use of existing facilities and equipment shall be given priority consideration in planning and establishing a recycling program.

4. Equipment, such as balers and shredders, available at a DoD installation or through Government Services Administration (GSA) shall be shared whenever possible to reduce costs.

5. Construction of holding bins and sorting platforms or other recycling facility improvements can be paid for with recycling money.

4.3.9.4 *Supplemental Funding Sources.* Within an installation, "seed" money for a QRP may come from the Central Base Fund, Service Headquarters funds, or other nonappropriated funds. The money can be in the form of a loan or a direct allocation.

4.3.9.5 Several funds are available through DoD's Productivity Enhancing Capital Investment (PECI) Program for a wide range of cost- and labor-saving capital investments which could include equipment or facilities in support of a QRP. Three funds are available that cover a broad spectrum of activities and functions. These funds operate under DoD Instruction 5010.36, which provides uniform project documentation formats and criteria for project selection and military post investment appraisal. The Fast Payback Capital Investment (FASCAP) is probably most applicable to a QRP. Each of the funds is briefly described below.

4.3.9.6 *Productivity Investment Fund (PIF).* PIF focuses on long-term investments with a payback period of 4 years or less. Investments are limited to projects with costs greater than $150,000.

4.3.9.7 *Component Sponsored Investment Program (CSIP).* The CSIP fund complements PIF but is more flexible. Investment limits and availability of funding vary depending on the annual budget allocation within each service.

4.3.9.8 *Fast Payback Capitol Investment (FASCAP).* Investments are limited to opportunities with costs ranging between $3,000 and $150,000. Projects selected for FASCAP financing must be expected to return costs within 2 years.

4.3.9.9 Projects are submitted on a year-round basis. See DoD Instruction 5010.36 for submittal procedures. Each project is reviewed to ensure that it conforms with restrictions established by public law or by DoD or service policies. It is then considered for financing in competition with other proposals. Since people are one of the Department's most costly and constrained resources, PIF projects promising personnel savings are given the highest priority in the selection process. However, other projects that produce significant savings in energy, material, or dollar resources are also financed through PECI funds.

4.3.9.10 *Transfer of Accountability and Custody.* Upon transfer of the waste to DRMO by an installation, the turn-in document (DD Form 1348-1)

must indicate that the material is recyclable, with funds to be deposited in a Budget Clearing Account. Account numbers exist for each installation and can be obtained from the base comptroller.

4.3.10 Resource Recovery and Recycling Program (RRRP) Operations. Once an RRRP has been justified and established, policies and procedures must be developed for operating the program. Although specifics may vary from installation to installation, many of the Policies & Procedures will be similar. A sample outline of policies and procedures is given below and shall be used for guidance only.

1. General Policies

   a. The purpose of an RRRP is to process recyclable material and to ensure participation by base personnel.

   b. Recyclable materials are defined as those products having no value other than their basic material content but which can be altered through chemical or physical processes. These materials include, but are not limited to, wood, metal, paper, glass, grease, petroleum products, and cardboard.

   c. The recycling plant (a designated building) serves as a staging area, warehouse, pickup and delivery point, and base of operations.

   d. Recyclable materials will be marketed and sold by the DRMO.

   e. RRRP will supply DRMO with pertinent information concerning type, quantity, and grade of recyclable material for sale.

   f. RRRP personnel will attend any local training or safety briefings relating to RRRP conducted by DRMO or any other base organization.

2. Procedures: Collection, segregation, processing, delivery, and shipment of recyclable materials by RRRP staff will be in accordance with procedures outlined herein and under the guidance of the local RRRP manager.

   a. Collection of ledger-grade paper:

      (1) RRRP will maintain a current list of Recycling Building Monitors, by facility, as supplied by the various Directorates, Commands, and Tenant organizations.

      (2) The local RRRP manager and Building Monitors will identify generating facilities and locate collection points within each facility.

      (3) All grades of recyclable paper will be segregated at the generating source by employees, military and civilian, of that facility according to current contract requirements, as

instructed by RRRP. Building Monitors will ensure compliance.

(4) RRRP staff will place canvas mail carts, or other suitable conveyances, at predetermined locations within those facilities that require them. Generators will store recyclable paper in said containers while awaiting pickup.

(5) The local RRRP manager develops regularly scheduled pickup routes for collection of ledger paper. The minimum frequency will be once a week. Generators whose volume of recyclable paper does not warrant a weekly collection will get a pickup when they have accumulated a minimum of 200 lb of material. RRRP staff will remove collected material within 3 days of notification by Building Monitors.

(6) RRRP paper collection teams, consisting of one motor vehicle operator (MVO) and one laborer each, will follow established collection routes in picking up recyclable paper:

(a) Team will ensure that all collection carts within a facility are accounted for.

(b) Team will empty all carts that are at least 1/2 full. Carts less than 1/2 full need not be picked up, at the discretion of the MVO.

(c) Team will roll, or otherwise carry, those carts which need to be emptied to the RRRP truck, or other assigned collection vehicle.

(d) MVO will ensure that paper is properly segregated.

(e) Improperly segregated or contaminated carts must be segregated and cleaned by the RRRP team. Properly segregated material will be emptied into Gaylord-type boxes carried upon the collection truck. MVO will ensure that sufficient boxes are on board the truck, and that said boxes are marked according to the proper classification of paper which they are to contain, in compliance with existing contracts.

(f) Carts that are contaminated by foreign materials to an extent greater than 25% are to be returned to their original location, unemptied. The building number, location number of office, and symbol of area where returned carts are located will be reported to the local RRRP manager.

(g) Carts that are soiled or damaged shall be replaced by new or clean carts. Soiled or damaged carts are to be returned to the recycling plant.

(h) MVO will keep a daily log using established format. Problem areas, i.e., contamination, lack of segregation, missing carts, are to be indicated on log. The local RRRP manger will contact appropriate Building Monitor in order to correct and prevent future deficiencies.

(i) Teams will pick up from bulk quantity generators and small volume generators according to procedures established and agreed upon by the RRRP manager and the Building Monitors.

(j) Gaylord boxes and bulk pickups will be delivered to the recycling plant at the end of the regularly scheduled route, immediately after bulk pickup, or when Gaylord boxes or truck is full, as good judgment and common sense would determine.

(k) Routes are to be complete within specified time limits as determined by the RRRP manager.

(l) MVO will unload Gaylord boxes with forklift and stack in assigned area according to established procedures. Partially full boxes are to be capped off before stacking.

(m) Team will unload bulk pickups and store on pallets in proper area of warehouse.

(n) Upon completion of daily routes, collection team will pack Gaylord boxes for shipment or perform other duties as assigned.

(o) MVO is responsible for daily maintenance and cleanliness of vehicles.

b. Cardboard Collection and Baling Operation:

(1) Cardboard will be delivered to the warehouse by RRRP personnel or other means according to established procedures.

(2) One sorter will be assigned to operate the cardboard baler.

(3) Sorter will separate trash and foam from cardboard and dispose of in trash dumpster provided.

(4) Clean, uncontaminated cardboard will be baled according to procedures outlined in baler operation manual.

(5) Sorter is responsible for baling all cardboard delivered to the baling pad on any given day, provided it is received no later than 1 h before quitting time.

(6) Sorter must broom sweep pad prior to leaving for the day and pick up any trash, paper, or cardboard not contained within the fenced-in area.

(7) Sorter is responsible for cleanliness of baling pad and equipment.

(8) Sorter is responsible for daily maintenance check of all equipment. Any potential problems shall be reported to the local RRRP manager.

(9) Sorter must follow all safety procedures established for baler operation.

(10) Upon completion of baling and cleaning, laborer is to assist in the wood grinding operation, shipping of paper, or other duties as assigned.

c. Metals Recycling:

(1) RRRP personnel will follow procedures outlined in DoD 4160.21 H, Defense Scrap Yard Handbook.

(a) Upon arrival in the scrap yard, RRRP personnel will remove material from trailers and place in the segregation area.

(b) RRRP personnel will identify material according to DoD scrap classification codes which are determined by proper application of one or more of the following listed tests:

1. magnet
2. visual
3. spark
4. chemical spot testing
5. electronic metal analyzer.

(c) Hoppers or engine cans bearing various scrap codes are provided to facilitate the segregation of metals. When a hopper is filled, it is weighed and dumped. Weight is recorded and forwarded to sales writers through the purchasing office. Also, shipping documents DD 1348-1 are coded with appropriate scrap class code and RRRP's financial accounting code when removed from the item during the identification process. Said documents are forwarded to the Documentation Section through the purchasing office.

(d) Sorters will perform first echelon maintenance on fork lifts and equipment used in the scrap yard.

d. Warehouse Operation:

(1) (Designated Building) will serve as warehouse and storage area for recyclable materials.

(2) The local RRRP manager or designated Work Leader will plot areas for storage of specific grades or other recyclable materials, as required, and identify certain areas for the segregation, shipping, and receiving of materials.

(3) Work Leader will ensure that all employees adhere to the warehouse planned functional layout diagram when receiving, loading, or shipping materials.

(4) Work Leader is responsible for daily maintenance and cleanliness of warehouse, equipment, and all plant facilities and grounds.

(a) Warehouse will be broom swept daily and mopped as needed.

(b) Outside perimeter of building is to be picked up and maintained on a daily basis. Trash, scrap, and debris are to be removed and deposited into an approved trash receptacle.

(c) Grounds adjacent to the warehouse, baler, and grinder pads are to be cleaned and maintained on a daily basis. No trash or debris is to be allowed to accumulate or scatter about the RRRP property nor be allowed to scatter or be carried by the wind beyond the confines of the fenced-in area.

(d) The local RRRP manager sets the standards for cleanliness.

(5) One laborer will be assigned to work on a prorated basis within the warehouse for the purpose of segregating recyclable materials.

e. Scrap Wood:

(1) The local RRRP manager will survey base collection points and identify wood scrap by the following categories:

(a) usable lumber for resale
(b) usable scrap for wood grinder
(c) unusable scrap.

(2) Collection personnel will deliver material to designated areas adjacent to the wood grinder located near the warehouse.

(3) Sufficient labor will be assigned to cut, break up, and segregate wood scrap according to Paragraph la.

(4) Laborers will operate the wood grinder according to Engineering Operating Procedures and existing safety regulations. Laborers must disassemble, cut, or otherwise break up usable scrap into sections conforming to the wood grinder specifications.

(5) Work Leader, or assigned MVO, will operate front-end loader, fork lift or other equipment, as needed, to assist laborers at the wood grinder.

(6) Wood grinder operators are responsible for daily maintenance check and continual observation of grinder operation to ensure that mechanical failures due to improper operation are avoided, thus minimizing equipment breakdown time.

(a) Operators will continually check metal separator for blockage or wood chip buildup.

(b) Operators will ensure that all wood fed into the grinder is free of any metal contamination other than nails, screws, and bolts less than 114 in. in diameter.

(c) Operators will report any problems, breakdowns, excessive reversal time, blockages, jam-ups or other mechanical difficulty to the local RRRP manager.

(7) No RRRP employee is to climb the conveyor belt or enter into the feed hopper of the wood grinder without expressed permission of the local RRRP manager and only when all power to the grinder has been disconnected and at least one other employee is on hand.

(8) Grinder operators are responsible for routine maintenance, such as greasing the grinder assembly and tightening or replacing drive belts.

(9) Operators are to maintain wood chip scrap in a controlled and neatly stacked manner to prevent chips from being spread throughout work area. All chips ground for resale on term contract are to be ground into the contractor's conveyance according to current contract obligations.

(10) Operators will clean and sweep the work area daily and dispose of any trash or debris in an approved trash receptacle.

(11) Laborers are responsible for the maintenance of all tools and equipment and are to return all tools and equipment daily to the tool box or tool storage area located at the warehouse.

3. Personnel: Manpower requirements are listed on the current Position Authorization Listing (PAL) on file at Naval Air Facility (NAF) Personnel. The RRRP manager determines manpower requirements and

includes same in NAF Income and Expense Budget in accordance with SSOI 176-3. If appropriated fund personnel are used, the manpower requirements will be identified by the RRRP manager and authorizations listed in the Unit Manpower Document.

4.3.11 Operational Checklist. Several approval requirements are necessary to officially establish and operate an RRRP. A checklist follows:

1. Has a Qualifying Recycling Program been established?

2. If appropriated fund personnel (military or civilian) are used to operate and/or manage the RRRP, is the proper account being repaid out of RRRP profits?

3. If MWR is selected to run the RRRP, have they been identified in writing as the Office of Operating Responsibility (OOR) for the base?

4. Has the appropriate personnel been appointed as the operational manager of the RRRP?

5. Has an operating instruction been established to cover the RRRP operation?

6. Are proceeds from sale of recyclable material deposited into the finance office?

7. Are accounting procedures being properly administered for RRRP funds?

8. Are DD Form 1348's being properly documented so the funds from sale of recyclable material are deposited to the base budget clearing account?

4.3.12 Strategies for Success. Generally, successful recycling programs will begin based on one or two profitable commodities. Then, as organizational and operational details get worked out, the program expands to include others. To be successful, any recycling program needs the attention of the base commander, at least initially. The programs require widespread publicity and support. Base newspapers and bulletins are essential media for publicizing the programs. Some lessons learned from successful service programs are listed below.

1. The key to a successful recycling program is education. People need to be convinced of the merits of the idea and must see some reward before they will participate. New family housing orientation sessions shall stress recycling. Contests with monetary rewards for the best participating unit generate and sustain interest in recycling.

2. Education should really begin at the grade school level so people are conditioned at an early age to appreciate the merits of recycling.

3. The recycling efforts should receive frequent publicity in the post's newspaper and through bulletin notices.

4. The procedure for recycling should be as painless as possible for participants. The higher the degree of separation requested at the source, the less volume of wastes one can expect to collect.

5. Sole source segregation is the optimum. However, source separation activity coupled with final separation, if necessary, at a resource recovery center for quality control is a good combination.

6. Refuse collection and resource recovery operations should be well-coordinated and cooperative activities.

7. A well-run recovery center can support its own key staff and still generate revenue for MWR and other approved projects.

8. Excess equipment from printing shops such as book binding cutters can pay for themselves in a few months. (Glued paper cannot be recycled so bindings must be removed from books and pamphlets.)

9. Carbon paper removal from multipart forms is quickly done with mechanical devices. Again, surplus warehouses are possible sources for such used equipment.

4.3.13 Financial Constraints. Most RRRPs will encounter cash flow problems at least during startup. Figure 4-3-13A shows a typical time cycle for submitting goods to DRMO and actually getting money back to the installation.

4.3.13.1 *Computerized tracking.* Several installations have learned to live with the payment delays by using a computerized tracking system. Personal computers are used to track dates, items, and quantities of materials sent to DRMO. The same system tracks bid prices and reimbursement dates from ORMO. This system ensures accurate reimbursement from DRMO and provides good predictions of income to the installation for periods 3-4 months in the future.

4.3.14 Recvcle Planning Board. At large installations, a Recycle Planning Board shall be established to:

1. identify potentially recyclable materials, gather data on sources and volume for use in feasibility and cost analysis, establish contact points within an entire installation, and monitor collection and segregation efforts.

2. consider and make recommendations on proposed expenditures for equipment required to segregate and/or store recyclable materials and for services such as material pickup.

3. promote and publicize the program.

4. collect nominations from the installation for projects to be funded by the program (projects submitted to the board must have been reviewed by the same local command echelons that would normally review such projects for funding from normal appropriations).

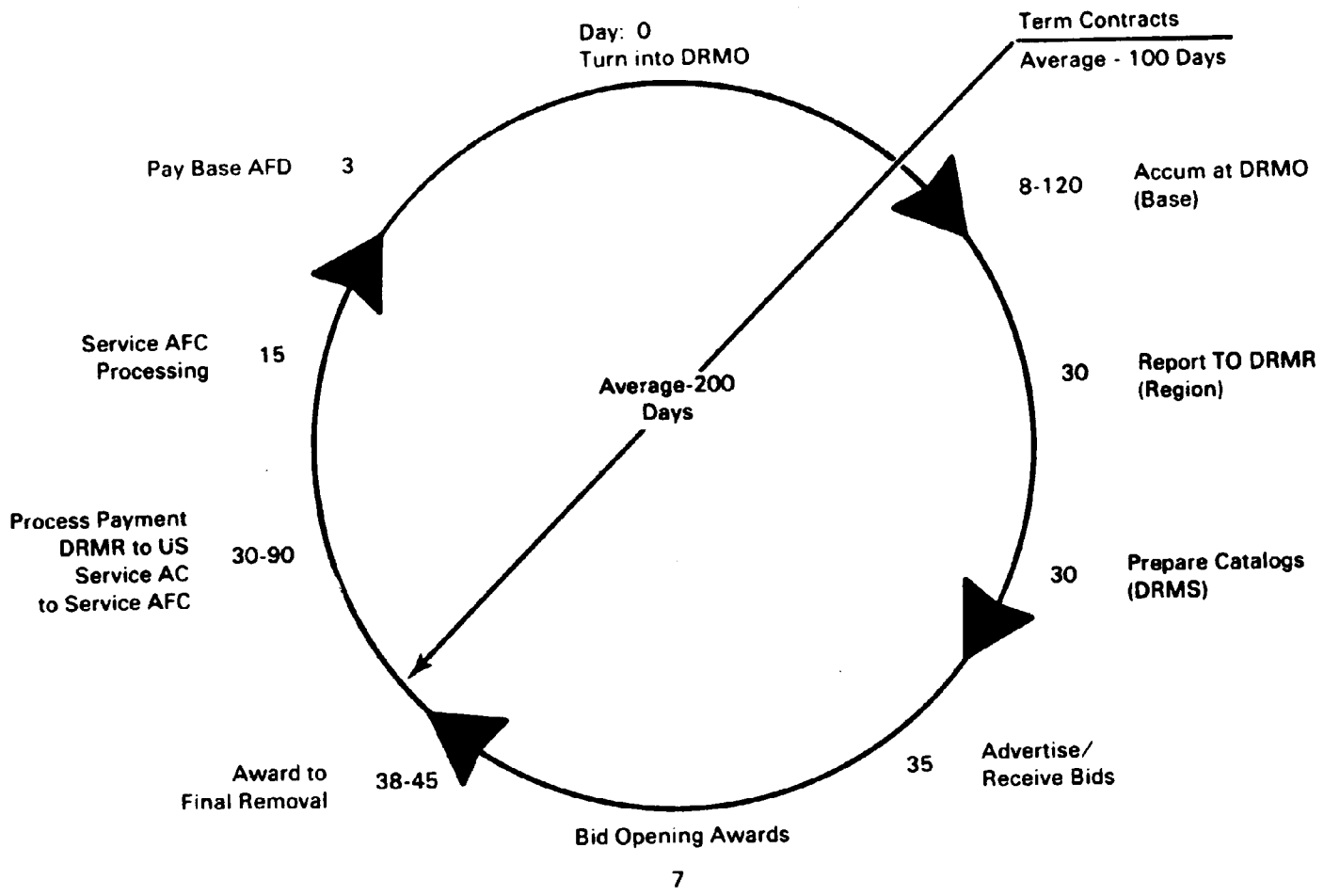


FIGURE 4-3-13A
Cycle Time for Submitting Goods to DRMO

5. prioritize projects for consideration in an annual program.

4.3.14.1 *Sharing ideas.* Lessons learned at one installation will save time and effort at other installations. An annual Tri-Service meeting on the sole subject of RRRPs would be an excellent way of presenting useful information, especially to new programs. Such a meeting should show a high return on investment simply by warning inexperienced bases about common pitfalls.

4.3.15 Audits

4.3.15.1 Any RRRP can be subject to an internal service audit or an audit by the Government Accounting Office.

4.3.15.2 The overall objective of an audit is usually to evaluate MWR participation in the RRRP and the internal controls in place to manage the funds generated by the program. Specifically the audits will

1. determine whether sound business practices were followed in establishing the RRRP.

2. evaluate the effectiveness and efficiency in managing the RRRP to determine whether procedures promote revenue maximization and cost minimization.

3. evaluate procedures to account for RRRP revenue to determine whether accountability is maintained from sale to receipt of cash and whether income reporting is consistent throughout the military.

4. determine whether all costs incurred in generating RRRP revenues are reimbursed prior to project funding and whether RRRP funds are being used in accordance with the intent of Public Law 97-214.

5. determine whether any abuses of Public Law 97-214 are occurring. The intent of the law is clearly to allow only revenues from the sale of scrap to accumulate in RRRP accounts. Reusable personal property is NOT to be sold as scrap.

6. determine whether installations with qualified RRRP's are receiving goods from installations without RRRP's. This practice is not recommended. Each installation shall establish its own RRRP even if some support is required from another installation.

4.3.16 Waste Segregation Options

4.3.16.1 *Segregating Wastes.* The mechanics of segregating recyclable materials falls between two extremes: source separation and disposal site separation. Source separation is defined as the setting aside of one or more recyclable materials, such as paper, cans, or glass, from refuse. This must be done at the point of generation by the discarding unit before the materials become mixed into the solid waste stream.

4.3.16.2 *Disposal Site Separation.* Disposal site separation generally uses mechanical equipment to separate recyclable materials from other

post consumer wastes. The simplest form is a conveyor belt manned by laborers who do the actual separation.

4.3.16.3 Separation of materials at final disposal sites generally requires a large investment in equipment and a large, steady supply of raw material to justify the equipment. Likewise, markets for the recovered materials must exist. For these reasons, few military installations practice disposal site separation. Techniques are mentioned here because some bases will utilize them in some form and future trends may show more extensive use because of increased costs for landfilling and incineration.

4.3.16.4 Recovery of Materials at Final Disposal Sites. This type of recovery is distinguished from source separation in that recoverable materials enter the waste stream and are mixed with nonrecoverable solid wastes. This method will generally require the use of specialized equipment or machines not normally found in the military supply system.

4.3.16.5 The overall success of a mechanized material recovery facility depends on the technologies utilized. Ferrous metal recovery has been proven effective at several locations, whereas aluminum recovery has achieved a less successful track record. For economic and health reasons, mechanically recovered paper is currently used almost exclusively for the production of refuse-derived fuel (RDF) rather than fiber recovery. As a result, technologies designed to recover fiber have received relatively less attention. Glass recovery technologies have achieved limited success; more than aluminum, less than ferrous metal.

4.3.16.6 The technology for separation of materials from military post consumer solid waste is generally used in conjunction with energy recovery systems. Several techniques are listed in Table 4-3-16A. The more common ones are discussed below.

4.3.16.7 Hand picking of recyclables from conveyors prior to discharge into transfer trailers or processing machinery is frequently practiced.

4.3.16.8 Magnetic separators usually consist of a belt, drum, or pulley with a magnet used to attract and remove magnetic materials from refuse or other materials (Figure 4-3-16A). At military industrial installations, cranes with electromagnetic hooks (Figure 4-3-16B) can be used to separate magnetic materials into large sorting bins.

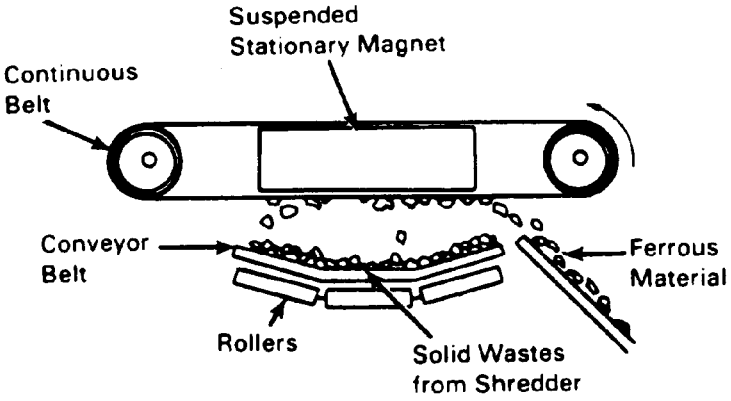
4.3.16.9 Eddy current separators are used to separate aluminum and other nonmagnetic metals using the properties of a magnetic field as a method of sorting. An alternating current is passed through a piece of metal causing it to become temporarily magnetic and thus deflected and separated.

4.3.16.l0 Heavy media separators use a suspension of finely ground, dense minerals in water. When the mixture of glass, aluminum, and other nonferrous metals is immersed in the liquid, the fluid density can be controlled so that the aluminum and glass float while the other metals sink.

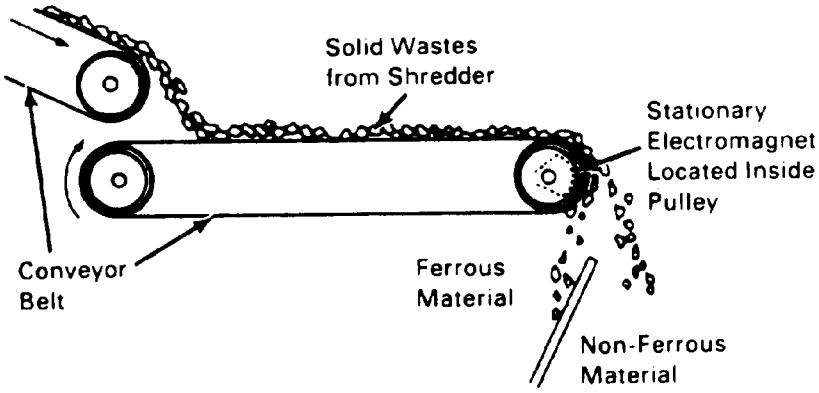
4.3.16.11 Equipment used in the paper industry can pulp waste paper and separate foreign matter. Hot water and agitation are used for pulping

TABLE 4-3-16A
Solid Wastes Separation Technique and Application Information
for Centralized Separation Facilities

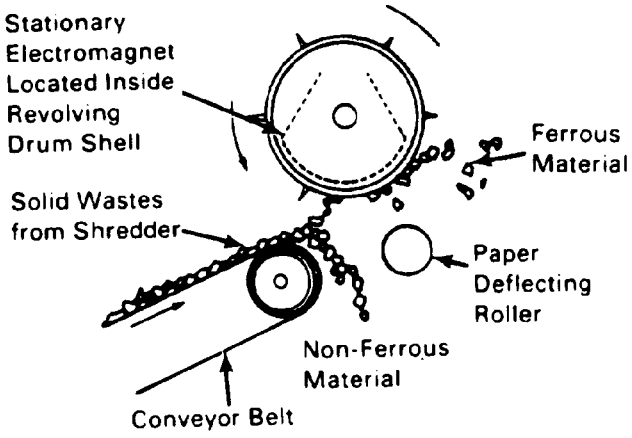
Technique	Material Involved	Preprocessing Required	Remarks
Handpicking and handsorting	Newspaper, corrugated paper	None	May be economical alternative to source separation, depending on labor costs.
Air separation	Combustible materials	Shredding	Used to concentrate metals and glass in a heavy fraction as well as combustible materials in a light fraction.
Inertial separation	Combustible materials	Shredding	Same as air separation.
Screening	Glass	None or shredding, air separation	May be used prior to shredding to remove glass and prior to air separation for similar reasons. May be used to concentrate glass-rich fraction from heavy fraction.
Flotation	Glass	Shredding, air separation	Water pollution control may be expensive.
Optical sorting	Glass	Shredding, air separation and screening	May be used as an alternative to flotation to separate glass from materials; also used to separate flint from colored cullet.
Electrostatic separation	Glass	Shredding, air separation, magnetic separation, and screening	Experimental.
Magnetic separation	Ferrous metal	Shredding or wet pulping	Proved in numerous full-scale applications.
Heavy media separation	Aluminum, other nonferrous metals	Shredding, air separation	May be used to separate a number of materials by adjusting specific gravity of media; separate units are required for each material to be separated.
Linear induction separation	Aluminum, other nonferrous metals	Shredding, air separation, magnetic separation, and screening	Individual units are required to separate aluminum and other nonferrous metals.



(a) Suspended Magnet



(b) Magnetic Pulley



(c) Suspended Magnetic Drum

FIGURE 4-3-16A
Magnetic Separator Designs

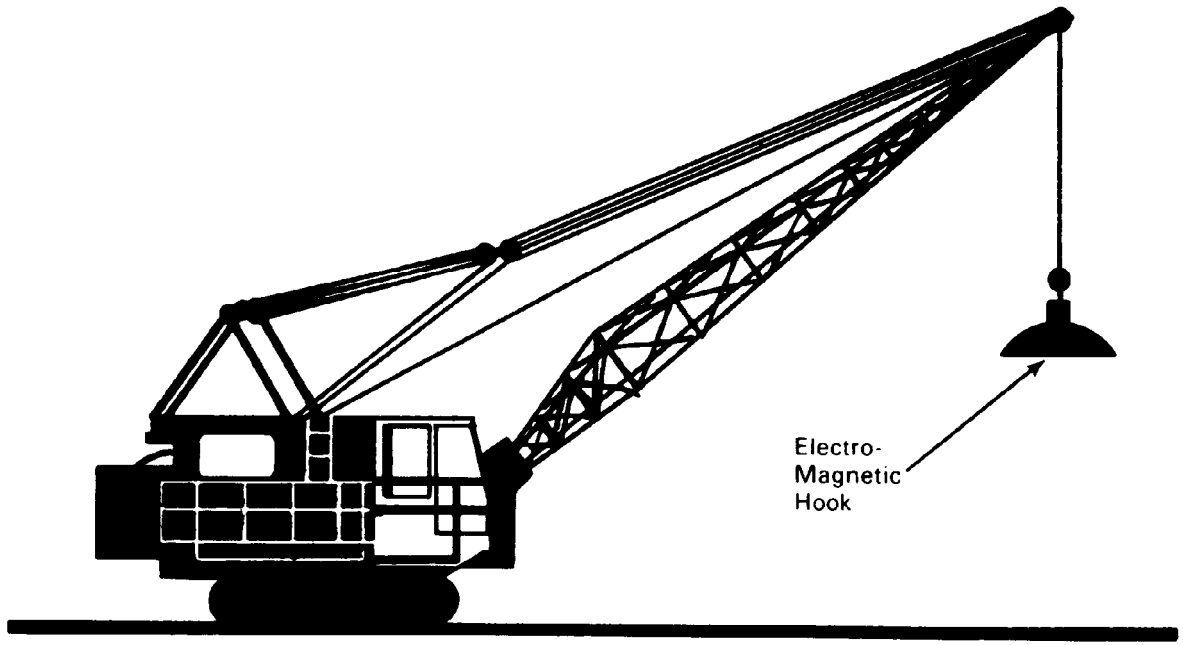


FIGURE 4-3-16B
Crane with Electromagnetic Hook

rather than chemicals. This process has been incorporated into certain resource recovery systems to recover paper fibers from municipal solid waste.

4.3.16.12 Source separation is usually preferred over separation of materials at the final disposal site because it is easier, less expensive, requires limited equipment, and generally results in a higher grade of recovered material. Disposal site separation does, however, yield concentrated recycle streams and shows reduced transportation costs over source separation/collection options.

4.3.16.13 *Source Separation.* DoD Directive 4165.60 (Dec 1986 Draft version) "Solid, Hazardous and Petroleum Waste Management" requires the recovery and recycling of solid and other waste materials to the maximum extent practicable. Source separation is one of the simplest methods of compliance with this requirement. Separation of other materials for which there is a market may be accomplished and is encouraged. A source separation program may be instituted at an installation only after the DRMO determines that markets exist for the separated materials. If markets do not exist, source separation is not required. The minimum requirements for source separation considerations are:

1. High-grade office paper -- any installation employing over 100 office workers.

2. Newspapers -- installations with more than 500 family housing units.

3. Corrugated containers (cardboard) -- installations where commercial establishments collectively generate more than 10 tons per month.

4.3.17 Recovery of Energy

4.3.17.1 General. Energy recovery is now becoming a very popular method for disposal of solid waste. The cost of disposal can vary substantially. An economic study must be done at each installation to determine if waste to energy is feasible. Sale of steam or electricity and tipping fees can provide income for large installations. This income must offset operating costs including maintenance. Maintenance costs are typically very high in large RDF units. For small incinerators (more typical at military installations), waste volume reduction is usually the primary goal. Here the cost of the incinerator (operating and depreciation) must be offset by savings in other waste disposal practices (e.g., landfill). (Some installations use incinerators to provide supplementary building heat especially in winter months.) At military installations, small incinerators are good candidates to supplement steam or hot water heating requirements. Generation of electricity usually requires large capacity furnaces such as those shown in Figures 4-3-17A and B to be economical. Few military installations are large enough to support an incinerator that produces primarily electricity. Table 4-3-17A lists processes for recovering energy from solid wastes either as thermal energy or stored chemical energy.

4.3.17.2 Energy recovery by incineration typically takes one of four different methods. The large-sized waterwall mass burning systems (Figure 4-3-17A) are generally preferred in smaller cities. The prepared fuels of RDF systems are favored where materials recovery is an important

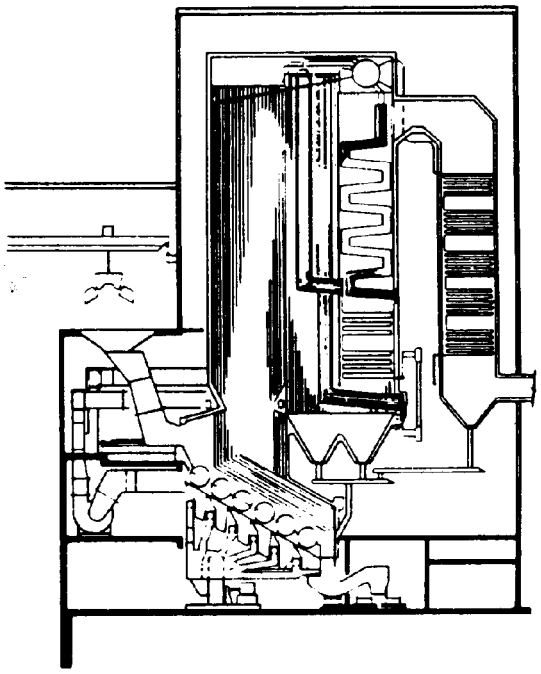


FIGURE 4-3-17A
Typical Waterwall Furnace Convention Boiler Systems Arrangement

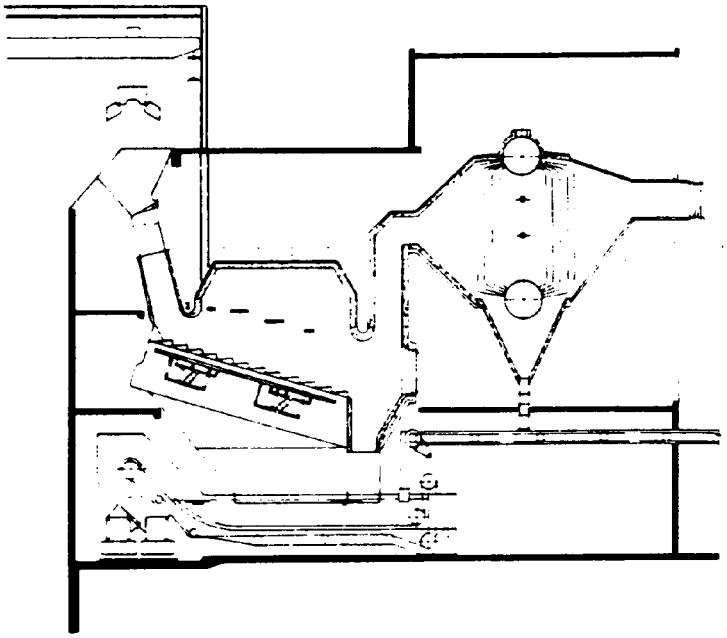


FIGURE 4-3-17B
Refractory Furnace, Convection Boiler Incinerator

TABLE 4-3-17A
Processes Used for the Energy Recovery from Solid Wastes

Process	Conversion Product	Preprocessing Required	Comment
Incineration with heat recovery	Energy in the form of steam	None	Markets for steam must be available; proved in numerous full-scale applications; air-quality regulations require extensive gas cleanup.
Supplementary fuel firing	Energy in the form of steam	Shredding, air separation, magnetic separation	If least capital investment desired, existing boiler must be capable of modification; air-quality regulations require extensive gas cleanup.
Fluidized bed incineration magnetic separation	Energy in the form of steam	Shredding, air separation,	Fluidized bed incinerator can also be used for industrial sludges.
Pyrolysis	Energy in the form of gas or oil	Shredding, magnetic separation	Technology proved only in pilot applications; even though pollution is minimized, air-quality regulations require gas cleanup -- different problems from incineration.
Hydrolysis	Glucose, furfural	Shredding, air separation	Technology on laboratory-scale only.
Chemical conversion	Oil, gas, cellulose acetate	Shredding, air separation	Technology on laboratory-scale only.

local issue. The modular mass burning combustion units with waste heat recovery are also popular (Figure 4-3-17B). LaRoc (1988) provides a good description of technologies currently available in the U.S. Modular mass burning units are probably the best choice for military installations. They provide flexibility to meet the changing needs of a base.

4.3.17.3 Much design and operating experience on municipal solid waste (MSW) combustion has been gained in Japan and Western Europe over the past decade as the volume reduction of wastes has been stimulated by the declining availability and increasing cost of landfills (Brna 1988). Nearly 2000 MSW units in Japan and several hundred in Western Europe are now operating, with the trend now being waste-to-energy conversion rather than simply incineration to reduce volume. Technology developed in Japan and Western Europe has been beneficial to the U.S., where over 100 MSW combustion systems are now operational, and a similar number are in the construction or conceptual development phase.

4.3.17.4 The reduction of waste volume by combustion results in air pollution, including pollutants not currently regulated by the EPA. Pollutants/emissions and methods of control require analyses in Environmental Assessments. Table 4-3-17B shows the U.S. standards along with those of several states and countries (Brna and Sedman 1987). However, the EPA has announced its intention to further regulate emissions from MSW combustors and proposes promulgation of these regulations in December 1990. Currently, studies are under way to determine which pollutants to regulate and to what extent. As indicated in Table 4-3-17B, classes of pollutants currently regulated by one or more of the entities listed include: trace organics (dioxins, total organics), acid gases (HCl, $S0_2$), trace heavy metals (Hg, Cd, Tl), and particulate matter. The listing in Table 4-3-17B is not intended to be complete. For example, West Germany regulates the emissions of more trace metals, and some U.S. states, as well as Japan and West Germany, have NO_x requirements/guidelines.

4.3.17.5 Noting the classes of pollutants that are currently regulated and their potential for regulation in the U.S.--on a national, state, or local level--the air pollution control strategy selected for a given plant shall have the potential for multi-pollutant control, if costly retrofitting or upgrading is to be minimized in meeting future regulations. Residues, although small in volume relative to unburned wastes, contain concentrated pollutants requiring environmentally safe disposition.

4.3.17.6 **Emission Control Technologies**

4.3.17.7 Historically, emission control on incinerators has focused on particulate removal. Tables 4-3-17C and D (Tchobanoglous, Theisen, and Eliassen 1977) show several equipment types and rate their relative performance in removing particles.

4.3.17.8 Recent developments and perceived trends have switched the emphasis to removal of acid gases, trace organics, and trace heavy metals.

4.3.17.9 Wet or dry scrubbers are effective for controlling pollutants (acid gases, trace organics, trace heavy metals, and particulate

TABLE 4-3-17B
Selected Emissions Standards for Municipal Waste Incinerators (Brna and Sedman 1987)

Emissions	U.S.(1)	California	Connecticut	Michigan	Japan	Sweden(2)	West Germany
Solid particulate matter, gr/dscf (mg/m^3)	0.046 (113)	0.01(3) (25)	0.015 (37)	0.015 (37)	0.061(4) (150)	0.008 (20)	0.012 (30)
Carbon monoxide, ppm	--	--	--	113 (24-h avg)	--	--	80
Hydrogen chloride	--	30 ppmv (scrubbers required)	90% reduction	90% reduction	430 ppmv (700 mg/m^3)	63 ppmv (100 mg/Nm^3)	31 ppmv (50 mg/Nm^3)
Sulfur dioxide, ppm	--	30 (6)	170 (0.32 lb/ 10^6 Btu) (7)	80	Varies(5)	New SO_2 limits reduce all acids	35 (200 mg/Nm^3)
Dioxins measured as 2,3,7,8 - tetrachlorodibenzo-p-dioxins (TCDD)	--	--	--	--	--	Existing plants: 0.5-2.0 ng/Nm^3 New plants: 0.1 ng/Nm^3	--
Total organics, mg/m^3	--	--	--	--	--	--	20
Mercury+Cadmium+Thallium, mg/m^3 (includes vapors)	--	--	--	--	--	0.05 (Hg only)	0.2
Gas correction	12% CO_2 dry	12% CO_2 dry	12% CO_2 dry	12% CO_2 dry	12% CO_2 dry	10% CO_2 dry	11% O_2 dry

(1) Revised pollution standards scheduled to be proposed in 1989.

(2) Swedish Environmental Protection Board's "Temporary Emission Goals," July 1986.

(3) California regulations permit more stringent local limits. Two state guidelines are reported: 0.1 gr/dscf (25 mg/m^3) for total solid particulates (TSP) and 0.008 gr/dscf (20 mg/m^3) for particles less than 2 μm.

(4) Based on continuous gas flows > 25,280 scfm (40,000 m^3/h). For flows ≤ 25,280 scfm, the particulate matter standard is 0.20 gr/dscf (500 mg/m^3). For new plants in special areas, this standard is 0.033 gr/dscf (80 mg/m^3) for plants having > 25,280 scfm and 0.061 gr/dscf for those having ≤ 25,280 scfm.

(5) Based on formula related to stack height and plant location. Typically, plant sulfur dioxide emissions range from 60 to 100 ppm so that control is not required except for new plants in special areas.

(6) Pollutant control requires use of the Best Available Control Technology (BACT), but no technology is specified.

(7) The use of dry gas scrubbers and baghouses is expected to improve removal over electrostatic precipitators alone.

TABLE 4-3-17C
Emission Control Facilities and Equipment for Municipal Incinerators

Item	Description
Settling chamber	A large chamber usually located immediately after combustion chamber for removal of large fly ash particles and as pretreatment operation for subsequent removal processes.
Baffled collectors	Baffles constructed of brick or metal that can be operated in wet or dry mode. Usually located after combustion chamber. Particles 50 μm or larger can be removed by impingement, velocity reduction, or centrifugal action. Efficiency depends on design and placement.
Scrubber	Fly ash is impacted on water droplets and subsequently removed. Method of removing wetted fly ash depends on equipment to be used and design of incinerator.
Cyclone separator	Dry separation of fly ash particles by means of centrifugal action in which particles are thrown or impinged against walls of collector.
Electrostatic precipitator	Fly ash particles are charged by means of an electrode. Charged particles are removed on collecting surfaces placed in an electrical field of high intensity. Once on the collecting surface, particles lose charge and adhere lightly. Can be moved by light tapping.
Fabric filter	Combustion gases are filtered through filter bags made of various materials.

TABLE 4-3-l7D
Comparative Air Pollution Control Data for Municipal Incinerators

Collector	Relative Capital Cost Factor, FOB	Relative Space %	Collection Efficiency, %	Water to Collector, gal/min/ 1000 ft /min	Pressure Drop, in. water	Relative Operating Cost Factor
Settling chamber	Not applicable	60	0-30	2-3	0.5-1	0.25
Multicyclone	1	20	30-80	None	3-4	1.0
Cyclones to 60-in, diameter	1.5	30	30-70	None	1-2	0.5
Scrubber	3	30	80-96	4-8	6-8	2.5
Electrostatic precipitator	6	100	90-97	None	0.5-1	0.75
Fabric filter	6	100	97-99.9	None	5-7	2.5

(1) Gases usually are cooled with water-spray scrubber before going to electrostatic precipitator.

Note: gal/mm x 0.0631 = L/s
ft^3/min x 0.028 = m^3/min
in. x 2.54 = cm
FOB = Free on board at the factory

matter) produced in burning MSW waste. The choice of scrubber type depends on the pollutants to be controlled and the degree of control required. Dry sorbent (lime) injection with an electrostatic precipitator (ESP) is used extensively in Japan for acid gas control, but wet scrubbing is preferred where high metals control is needed. The ESP/wet scrubber combination appears to be favored in West Germany for plants started up in the past decade and those expected to start up in the next several years. In the U.S., the lime spray absorption/fabric filter system is now frequently being selected for multi-pollutant control.

4.3.17.10 Acid gas removals of 90% or more have been achieved with a lime circulating fluid bed or lime spray dryer absorber preceding a fabric filter or ESP. Wet scrubbing preceded by an ESP is at least as effective as the systems noted when used to control acid gases. These systems are also effective for controlling organics and trace heavy metals, with mercury control appearing to be improved at lower temperatures and when a fabric filter rather than an ESP is used. Both the ESP and fabric filter can meet current particulate control requirements, but the fabric filter may have the edge for multi-pollutant control. More data, especially from commercial units under long-term operation, are needed to more fully quantify the performance of scrubbers designed to remove trace organic compounds and trace heavy metals.

4.3.17.11 Although stack gas cleanup is one answer to pollutant control, minimization of pollutants can also be achieved by careful combustion control. This has been shown to be true for control of the dioxins polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF).

4.3.17.12 There can be many reasons for the formation and destruction of dioxins. Dioxins can enter in the MSW, be created in cold regions of a furnace, be destroyed in combustion, form in the cooler outlet sections of the boiler, and “all of the above" (Hasselnis 1988).

4.3.17.13 Vogg, Metzger, and Steiglitz (1987) have found from extensive laboratory research as well as field tests on an MSW incinerator that

- Formation of PCDD and PCDF takes place at temperatures ranging from 390^{0}F to 750^{0}F. No effect on dioxins and furans occurs at temperatures below 390^{0}F; a sharp peak in both dioxins and furans occurs at 570^{0}F, and they are destroyed at 750^{0}F.

- In this temperature range, formation of PCDD and PCDF leveled off after about 6 h, but in 30 mm about 20% conversion had taken place.

- Oxygen concentration influenced formation of PCDD/DF linearly: zero oxygen resulted in decomposition or no formation; increasing oxygen levels resulted in a reduction in the fraction of dioxins and furans having the more toxic 4-chlorine forms (congeners) and an increase in fraction of less toxic forms having 6 to 8 chlorine molecules attached.

- Moisture strongly influenced dechlorination, causing formation of the highly toxic penta and tetra (4- and 5-chlorine) isomers.

- Only trace PCDD/DF was detected in boiler fly ash deposits in the second and third passes of the boiler as the gases cooled from 1470^{0}F to 750^{0}F, but substantial amounts were found in the fourth pass where the gases cooled from 750^{0}F to 425^{0}F.

- Copper chloride ($CuCl_2$), together with the alkali/alkaline chlorides in the fly ash, appears to play an important catalytic role, releasing free chlorine in reactions which take place on carbon surfaces.

- The hydrochloric acid (HCl) is oxidized from alkali and alkaline earth chlorides (such as KCl), also releasing chlorine to react with carbon.

- The amount of carbon in the fly ash appears to affect formation of PCDD/DF directly by the well-known Deacon process in which HCl is oxidized to $C1_2$ with airborne oxygen. Carbon can be reduced by good combustion, and is probably a useful indicator for dioxins and furans.

Vogg, Metzger, and Stieglitz (1987) conclude that good combustion, reduction of precursors such as carbon, and cleaning of the boiler surfaces are the primary measures that can be used to minimize dioxins, and suggest that ammonia could be used to poison the catalysts for the PCDD/DF reaction.

4.3.17.14 Guidelines

4.3.17.15 The following guidelines apply to incineration of military solid waste:

- Solid wastes will be incinerated only in facilities specially designed for that purpose.

- Design and operation of incinerator facilities shall be in accordance with the EPA guidelines for Thermal Processing of Solid Wastes (40 CFR 240).

- Design and construction of new incinerator facilities will be preceded by an assessment of the environmental impact of that facility in accordance with the National Environmental Policy Act, Council on Environmental Quality Regulations (EPA regulations 40 CFR 1500-1509) and agency regulations of each Military Department.

- The collection system and operation of the incinerator shall be planned so that toxic materials, bulky wastes, flammable or explosive wastes, or other materials not suitable for incineration are disposed of by other means. Wastes requiring special handling are discussed in Section 4.4. Highly flammable or explosive materials, such as gasoline, oil, tar roofing, photographic film, and ordnance, shall only be incinerated in an incinerator specifically designed for that purpose. Violations of this rule will subject incinerator personnel and equipment to unacceptable risks. Disposal of pesticides and pesticide containers is discussed in Section 4.5.

4.3.17.16 Some materials are unsuitable for incineration because they would cause damage to the incinerator. Where refuse is disposed of by incineration, installation regulations will specify the various segregations of refuse. The following materials are not suitable for incineration and will be rejected by the operator with the proper authority notified.

- *Hazardous refuse.* Reject all hazardous refuse of the types described in Section 4.5. Fine dust, flour, and powdered sawdust are also potentially hazardous when charged into the incinerator in large compact quantities. If care is exercised, they can be charged safely in small quantities.

- *Noncombustibles.* Metal, glass, ashes, and the like do not burn readily at normal incinerator temperatures. They form a slag, foul the grates, increase stoking requirements, reduce burning capacity, and finally must be removed from the furnace. Small quantities of tin cans and wire bindings will not materially affect incineration; operations shall not be delayed to sort them out.

- *Excessive moisture.* Refuse containing a high percentage of liquid shall be rejected. Excessive liquid will slow combustion and damage hot refractories and castings.

- *Lumber.* Burning lumber releases more than four times as much heat as ordinary combustible rubbish. Heavy construction lumber and crating shall not be charged in large quantities into a Type I[1] or Type II incinerator. An operator can mix this material in small quantities with Type I and Type II wastes. Type III or an industrial destructor can also be designed to incinerate this material.

4.3.17.17 Incinerator facilities must provide for receiving, weighing, unloading, storage, charging, combustion, emission control, and removal and handling of residues. Principal components in the design of an incinerator are shown in Table 4-3-17E.

4.3.17.18 Safe incinerator operation and maintenance shall be a primary concern. Personnel shall have a short safety meeting just before the commencement of maintenance work.

- Dampers in the ducting shall be closed during servicing of induced/forced-fans to prevent downdraft/updraft from turning the fans and causing injury.

- Materials handling equipment (MHE) shall be inspected daily by operator and load tested at least annually.

- Storage tanks, silos, manholes, and process equipment shall be checked by a gas-free engineer before personnel enter. Personnel inside a confined space shall have a lifeline and a buddy with visual contact at all times.

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[1] See Table 4-3-17G.

TABLE 4-3-17E
Principal Components in the Design of Incinerators

Component	Purpose/Description
Scales	Required to maintain accurate records of the amount of wastes processed.
Storage pits	Design of pits depends on furnace capacity, storage requirements (approximately 1-day capacity), collection schedules, and truck-discharge methods.
Cranes	Used to transfer wastes from storage pit to charging hoppers to mix and redistribute wastes in storage pit.
Charging hoppers	Constructed of metal or concrete, used to introduce wastes to furnace grates.
Furnace grates	Used to move wastes through furnace. Traveling, reciprocating, rocker arm, and barrel grates have been used successfully. Burning rate of 60 to 65 $lb/ft^2/h$ has been adopted as a “generally allowable" standard for mass firing.
Combustion chamber	Depends on capacity of unit and fuel characteristics.
Heat-recovery system	Types of systems vary. Typically, two boiler sections are used: convection and economizer.
Auxiliary heat	Need depends on moisture content of wastes as delivered.
Air pollution control facilities	Used to control particulate and gaseous emissions.
Auxiliary facilities and equipment	Normally includes residue handling facilities, air supply and exhaust fans, incinerator stacks, control building, etc.

4.3.17.19 Recommended facility safety features are shown in Table 4-3-17F.

4.3.17.20 Table 4-3-17G shows a range of incinerator sizes that might be considered by military installations. Many installations benefit from small capacity incinerators which might operate only 8 h/day. Rarely would a military installation consider a 1000-ton/day plant unless it was operating as a partner with municipalities. An example of such a cooperative effort is an RDF plant built by the Southeastern Public Service Authority (SPSA) (Masley 1987). Here the Norfolk Naval Shipyard participates both by supplying garbage and purchasing steam energy. Eight other communities are involved in this combined facility which consists of nine transfer stations, an ash landfill, and a refuse-only landfill in addition to the incinerator to serve a fast growing area. This incinerator capacity is roughly 2000 tons/day.

4.3.17.21 Operation Procedures

4.3.17.22 Maximum incinerator efficiency is obtained with continuous operation. However, military installations usually do not generate enough waste to justify this schedule. Except at the largest installations, one person, working an *8-h shift, can operate an incinerator that has sufficient capacity to burn all installation refuse during the working day. Cleanup is mandatory before and after firing. If the workload is too heavy, additional operators can be assigned. A staggered schedule will provide an adequate crew during peak delivery hours. The following typical staggered schedule allows 2 h for morning and evening cleaning and 9-1/2 h for incineration at full burning capacity.

1. 0700 - 1530: The first operator cleans the furnace and builds a fire from 0700 to 0800, then supervises the unloading and charging of refuse.

2. 0900 - 1730: The second operator stokes the fire and controls the rate of charging. From 1630 to 1730 the same operator accomplishes incinerator shutdown and ensures that the facility is left in a safe configuration.

4.3.17.23 Any furnace manufacturer will supply detailed technical operating instructions for the equipment. General plant procedures shall ensure that

- Personnel are provided with face shields or safety goggles, heavy gloves, respirators, safety shoes, and hard hats. OSHA Standard 1910.133 is the requirement for eye and face protection.
- Safety belts are worn when personnel are working on ladders.
- Fly ash is removed from the flues only when the ash temperature is below 38^{0}C (100^{0}F).
- Procedures for operation during emergency situations, such as power failure, air or water supply failure, equipment breakdowns, and fires, are developed and posted. These procedures shall be practiced so that personnel become familiar with them and able to apply them when necessary.

TABLE 4-3-17F
Facility Safety Features

1. Shredder to reduce size of lumber and other combustible refuse being charged to the furnace. Oversized wood or lumber causes bridging in the charging hopper, which may cause flame propagation and combustion of solid waste outside the furnace.

2. Automatic or manual sprinkler systems for storage pits and charging floors.

3. Fire-hose stations and fire extinguishers at strategic locations for fire protection. Sprinklers in the charging hoppers are needed to put out fire backlash.

4. Good lighting.

5. First aid kits in dumping and furnace areas.

6. Adequate drains and sloping floors.

7. Building ventilation using outdoor suction intakes to prevent the possibility of creating a vacuum on the stoking floors.

8. Stacks equipped with aircraft warning, lightning rods, and safety ladders.

9. Stack sampling ports as required by air pollution control regulations.

10. Intercom system between charging and stoking floors.

11. Provide TV monitors in the control room for the charging hoppers, dumping area of the refuse pit, end of the furnaces, and the stack. The monitors will help the operators control various plant operations.

12. Access ladders to storage pits.

13. Forced-air ventilation in storage pits.

14. Drains to allow hosing of the storage pits.

15. A method of quickly removing an injured person from the storage pit.

16. Chimney screens.

17. Guardrails to prevent personnel from falling into the incinerator equipment. At the charging opening of top-fed incinerators, toe boards as well as guardrails will be provided. OSHA Standard 29 CFR Part 1910.23 refers to guarding openings in floors.

18. Permanent, fixed backing bumpers to prevent vehicles from backing into the storage pit.

TABLE 4-3-17F
(cont'd)

19. Overhead cranes equipped with an alarm to indicate that the crane is in motion.

20. Safety valves in any facility designed to generate steam or hot water.

21. Provide a quench tank for ash to put out embers and prevent re-ignition of unburned solid waste. Building ventilation shall be designed so that foul air from the refuse pit, segregation areas, etc. is conveyed to the furnace as part of the primary combustion air for sanitation and odor control.

TABLE 4-3-17G
Types and Capacities of Incinerators

Type	Solid Waste Type	Capacity
Army 1[1] (most used)	100% combustible to 65% dry rubbish + 35% wet garbage	0.6 ➜ 1.2 tons/h
Army 11[1]	35% dry combustible rubbish + 65% wet garbage	3, 5, 10 tons/8-h shift
Army 111[1]	Special handling of unique disposal problems, usually waste with <15% moisture	Varies
Packaged Controlled	Waste with heating value ~65OO Btu/lb; usually have auxiliary burners fired with oil, gas, or both.	➜ 1.5 tons/h
Commercial municipal Continuous feed a. traveling grate b. reciprocating grate c. rotary kiln d. barrel grate e. waste heat recovery	Designed to fit waste stream -- need a steady supply of waste within narrow composition limits.	➜ 1000 tons/day

(1) tm 5-814-4 (Incineration)

- Safety valves are removed and checked at least once a year by qualified mechanics.

- Electrical equipment such as forced-draft motors, switches, and wiring, is serviced and maintained by qualified electricians

- Good housekeeping is practiced at all times.

- Appropriate warning signs and instrumentation are conspicuously posted. Charts and signs serve to familiarize personnel with correct operating practices. An incinerator operating chart can be used as a visual guide for stokers and chargers. Warning signs shall be posted as reminders to keep personnel outside guardrails. Prominent posting of the notices to collection crews will alert truck drivers and helpers to safe, orderly procedures. For timely maintenance, a schedule shall be displayed, giving desirable frequency for inspecting refractories and cleaning ash pits, fire chambers, combustion chamber, stack base, floors, sumps, and floor drains.

4.3.17.24 **Maintenance procedures.** Components subject to rapid wear or damage shall be inspected weekly at a time when they are not in operation. After each weekly inspection a report shall be made. It shall include the condition of the furnace, repairs performed, and the expectation of future repairs. When repairs are being made, the units remaining in operation should not be overloaded. Some incinerators are equipped with maintenance shops. Spare parts (those not readily available as shelf items) for cranes, stokers, fans, and motors are sometimes kept on hand. Most operational maintenance is performed by regular staff employees. Preventive maintenance should be practiced to prevent serious problems. Weekend shutdowns provide an excellent opportunity to inspect for future problem areas. Refractory maintenance, boiler care, slag removal, and grate maintenance are some of the important areas that shall be serviced frequently. In addition to the control of odor, dust, and litter, the work space shall be kept clean. Misuse of employee facilities, such as accumulating salvage items, shall not be permitted. Poor housekeeping creates fire or safety hazards. Lighting fixtures and bulbs shall be kept clean to provide effective illumination at all times.

4.3.17.25 **Disposal of Residue.** From 5% to 25% by weight of the refuse charged into an incinerator remains as residue after combustion. The percentage for a given facility depends upon the composition of the waste stream, preincineration resource recovery, and operation of the incinerator itself. Devices to handle this residue differ, depending on the type and design of the incinerator. The residue contains all of the solid materials remaining after burning such as ash, cinders, unremoved metals, glass, rocks, and unburned organic substances. Incinerator residue is permeable and contains water-soluble inorganic and organic compounds. Incinerator residue must be analyzed to determine if it is regulated as a RCRA waste or by state or local regulations. Batch-feed incinerators usually have ash hoppers located directly below the grates. The hoppers are large enough to store the refuse from several hours' burning. The residue is quenched or sprayed with

water to reduce fire hazards and to control dust. Many incinerators are designed to allow dump trucks to load the residue directly from the hoppers. The residue from continuous-feed furnaces falls from the burning grate into automated ash removal devices. The residue is also quenched in a bath for dust and fire control. A drag or apron pan conveyor then carries the wet residue to dump trucks. The quench water requirements will vary considerably depending on the specific design and operational requirements of a given incinerator. Ash after quenching is then disposed of according to federal, state, and local regulations.

4.3.18 Composting. Composting is another resource conservation method. It is the process whereby microorganisms are utilized to convert most organic matter to humus. The resulting humus is generally used as an agricultural soil conditioner or potting soil. Composting could theoretically have a wide application to many military installations since they are frequently located in wooded areas. Composting operations at installations located in areas possessing an abundance of leaves can significantly reduce the volume of wastes to be disposed of.

1. Leaves can be bagged by residents and set out at the curb for pick-up on specified days. Leaves from parade grounds and other nonresidential areas can be raked into large piles and loaded directly into dump trucks or other general purpose vehicles. All leaves can then be hauled to a central composting point. An excellent location for the composting point is the installation sanitary landfill. The composting operation can be placed on a completed and filled section in the landfill site. Once at the composting site, leaves shall be arranged in rows and turned frequently in order to promote rapid decomposition. The resulting humus can be utilized on the installation as a soil conditioner or potting soil.

2. Pine straw is considered a forestry product and specific regulations apply to its disposal. Pine straw is available in large quantities at many military installations, particularly in the southeastern United States. The pine straw may be composted, but it can also be used as is without further processing. It has excellent usage as the top cover in flower beds and in forming "pine islands." Pine straw may also be given to civilian communities for use in community beautification projects. Pine straw with commercial value cannot be given away.

3. Solid waste can also be composted. The waste is usually shredded, and most of the nonorganic materials removed. The remaining organic material is generally arranged in windrows and turned frequently to promote decomposition by microorganisms. The resulting humus can be utilized in the same manner as that generated from leaves. This operation shows limited applications to military installations. The Navy and the city of Key West jointly constructed a 50-ton/day aerobic composting facility in Key West, Florida. Solid waste is mechanically composted and windrowed onsite (one turn every week for 90 days). The product is a soil conditioner used on city parks and sold to the public.

4. Composted leaves and pine straw are generally utilized at the generating installation, and marketing is not a consideration. However, there are several disadvantages to the composting of solid waste. The processing required for its preparation is similar to that for RDF, and it is unlikely that composting will be able to compete with energy recovery as a solid waste management tool. Also, compost is considered to be a very low grade fertilizer and as such cannot economically compete with available chemical fertilizers. Finally, only a very few areas of the U.S. are so sandy that there is a great need for this type of soil conditioning. The high processing costs and lack of suitable markets will frequently result in making the composting of military solid waste economically unfeasible.

4.4 WASTES REQUIRING SPECIAL HANDLING

4.4.1 Many solid wastes may not be disposed of as normal municipal refuse and require special handling and/or disposal. Check with the installation environmental specialist for information regarding special handling and disposal requirements. The RCRA defines a solid waste as "any solid, liquid, semi-solid or contained gaseous material which has served its purpose or has been discarded." Materials that are recycled, reclaimed, or reused may be considered a solid waste under RCRA. Hazardous wastes, a subset of solid wastes, are wastes that pose "a substantial hazard (present or potential) to human health or the environment when improperly managed or disposed." Waste generators are responsible for determining which wastes are considered hazardous by regulation and which wastes shall be prudently managed as such. State and local regulation pertaining to solid waste disposal must be examined because RCRA allows the EPA to authorize individual states to operate their own hazardous waste management programs. The state programs must be equivalent to or exceed the federal regulations. Some states have adopted regulations that exceed certain portions of the federal regulations. For example, seven states have chosen to regulate infectious wastes as a hazardous waste. Other states may not recognize the "small quantity generator" status defined in the federal regulations.

4.4.2 Examples of solid wastes that may be regulated or require special handling are presented below:

- used oils and solvents
- asbestos wastes
- radioactive wastes
- infectious wastes
- PCB wastes.

The management of RCRA-regulated "Hazardous Wastes" is discussed in further detail in Section 4.5 of this document. Solid wastes considered to be hazardous wastes have been introduced in this section because they may be regulated by local, state, or federal regulations other than RCRA.

4.4.3 Used Oils and Solvents

4.4.3.1 Used oil includes all used petroleum products and lubricants, hydraulic fluids, preservatives, metal-working fluids, waxes, and insulating fluids. Used oil recycling and disposal activities are presently regulated under RCRA and various state authorities. The burning of used oil in nonindustrial boilers is prohibited if fuel specifications cannot be met because of contamination (chlorinated solvents; heavy metals; or polychlorinated biphenyls, PCBs), characteristics (flash point below 140^{0}F), or total halogens. Industrial burners of off-specification used oil fuel must comply with various notification, certification, and record-keeping requirements.

4.4.3.2 Used solvents are defined as all organic fluids contaminated as a result of use for cleaning or thinning or use as a solvent, antifreeze, or for a similar purpose. Most used solvents are regulated by RCRA as hazardous wastes. The recycling, reclaiming, or reuse of used oil or solvent may also be regulated. The Used Solvent Elimination Program (USE) requires the minimization of solvent wastes. Guidance for the management of used oils and solvents can be found in "Used Oil and Solvent Recycling Guide," prepared for NEESA in June 1985, and in NEESA 20.3-013. PCB-contaminated oils must be handled and disposed of as described later under PCB wastes.

4.4.4 Asbestos Wastes. Friable asbestos wastes must be handled and disposed of in accordance with the provisions of Subpart M of 40 CFR 61 and any other state or local regulations. Asbestos removal and disposal on military installations must be performed by a licensed contractor or specifically trained and equipped civilian/military personnel. The material must be placed in sealed, impermeable bags and disposed of by burial at a state-approved sanitary landfill.

4.4.5 Radioactive Wastes. The handling and disposal of radioactive wastes is strictly controlled by the U.S. Nuclear Regulatory Commission (NRC) in accordance with 10 CFR 20. Medical and research installations may produce wastes contaminated with radioactivity. Many of the short half-life radioactive isotopes used in medical activities can be decayed for 10 half-lives and then disposed of as infectious waste. Radioactive wastes containing regulated hazardous chemicals are considered "mixed wastes" and must be handled and disposed of as a "hazardous waste" and a "radioactive waste." For example, waste liquids used from scintillation counting may contain toluene or xylene, which are regulated hazardous chemicals wastes.

4.4.6 Infectious and Medical Wastes. Hospitals and other health care facilities generate solid wastes, of which 10% to 15% are considered infectious waste. Facility Engineers/Public Works Officers/Base Civil Engineers are not responsible for the collection and disposal of infectious waste. Commanders of medical department installations are responsible for the disposal of infectious waste in coordination with facility engineers/public works officers/base civil engineers. The regulation of infectious waste varies widely from state to state. The Medical Waste Tracking Act of 1988 required EPA to develop infectious waste regulations, which were issued under Subpart J of RCRA. Effective 22 June 1989, hospitals, clinics, medical offices, and other handlers of potentially infectious medical wastes in the states of Connecticut, New York, New Jersey,

Pennsylvania, Ohio, Indiana, Illinois, Michigan, Wisconsin, and Minnesota must adopt a tracking program to trace the wastes from generation to disposal for the next 2 years. Any of the Great Lakes states may "opt out" of the program, and other states may "opt in" to the program.

4.4.6.1 Generators and handlers of more than 50 lb of medical waste a month are required to complete a tracking for each waste shipment for offsite treatment or disposal. Generators of less than 50 lb of medical waste a month must keep logs at the generating site. All regulated medical waste managed offsite must be labeled and packaged in rigid leak-resistant containers in accordance with the regulations. Medical wastes are defined by the Act to include:

- cultures and stocks of infectious agents and associated biologicals
- cultures and infectious agents from research and industrial labs
- discarded live and attenuated vaccines
- culture dishes and transfer devices
- human blood and blood products
- organs and tissues removed during surgery and autopsy
- sharp instruments used in patient care
- contaminated animal bodies and parts exposed to agents in research and production of biologicals and drugs
- other lab wastes and equipment that may have come into contact with infectious agents.

4.4.6.2 The disposal of surplus medical supplies (FSC 6505) must also be considered. Some items contain silver, which can be recycled. Others such as outdated drugs and vaccines must be disposed of according to prescribed procedures. Procedures for disposal of surplus medical items are currently under development and revision.

4.4.6.3 *EPA Guidance.* Regulations for infectious waste management can be found in Environmental Quality, Preventative Medicine for Medical Services (e.g., AR 40-5). The EPA Office of Solid Waste has also published a document that provides guidance on the management of infectious waste, "EPA Guide for Infectious Waste Management," 1986, 530-SW-86-014. This document outlines procedures for designation, segregation, packaging, storage, transport, treatment, and disposal of infectious waste. The categories of wastes listed in Table 4-4A are recommended by EPA to be designated as infectious waste. EPA believes that the decision to designate the miscellaneous contaminated wastes presented in the table as infectious shall be made by a responsible authorized person or committee at the facility. EPA recommends that wastes from patients that are known to be infected with blood-borne diseases be treated as infectious waste.

TABLE 4-4A
Designation of Infectious Waste

Waste Category	Examples
Isolation wastes	! refer to Centers for Disease Control (CDC), Guidelines for Isolation Precautions in Hospitals, July 1983
Cultures and stocks of infectious agents and associated biologicals	! specimens from medical and pathology laboratories ! cultures and stocks of infectious agents from clinical, research, and industrial laboratories; disposable culture dishes, and devices used to transfer, inoculate, and mix cultures ! wastes from production of biologicals ! discarded live and attenuated vaccines
Human blood and blood products	! waste blood, serum, plasma, and blood products
Pathological waste	! tissues, organs, body parts, blood, and body fluids removed during surgery, autopsy, and biopsy
Contaminated sharps	! contaminated hypodermic needles, syringes, scalpel blades, Pasteur pipettes, and broken glass
Contaminated animal carcasses, body parts, and bedding	! contaminated animal carcasses, body parts, and bedding of animals that were intentionally exposed to pathogens
Miscellaneous Contaminated Wastes	Examples
Wastes from surgery and autopsy	! soiled dressings, sponges, drapes, lavage tubes, drainage sets, underpads, and surgical gloves
Miscellaneous laboratory wastes	! specimen containers, slides, and cover slips; disposable gloves, lab coats, and aprons
Dialysis unit wastes	! tubing, filters, disposable sheets, towels, gloves, aprons, and lab coats
Contaminated equipment	! equipment used in patient care, medical laboratories, research, and in the production and testing of certain pharmaceuticals

4.4.6.4 *Packing and Storage.* Regulations require units and installations that generate infectious waste to segregate and store the waste in the area of generation until collected. Distinctive, clearly marked containers with tight-fitting lids and lined with an appropriate bag (normally red) shall be used for most solid or semi-solid infectious waste. Container liners are to be tightly sealed with twist ties, rubber bands, and/or taped before leaving the area of generation. Puncture-resistant containers shall be used for needles, syringes, and sharps. Liquid wastes shall be placed in capped or tightly closed bottles or flasks until treatment and disposal. When storage of pathological waste is necessary, the enclosed waste will be refrigerated until transferred for treatment. Infectious wastes shall be collected at regular intervals by properly trained personnel to minimize storage time.

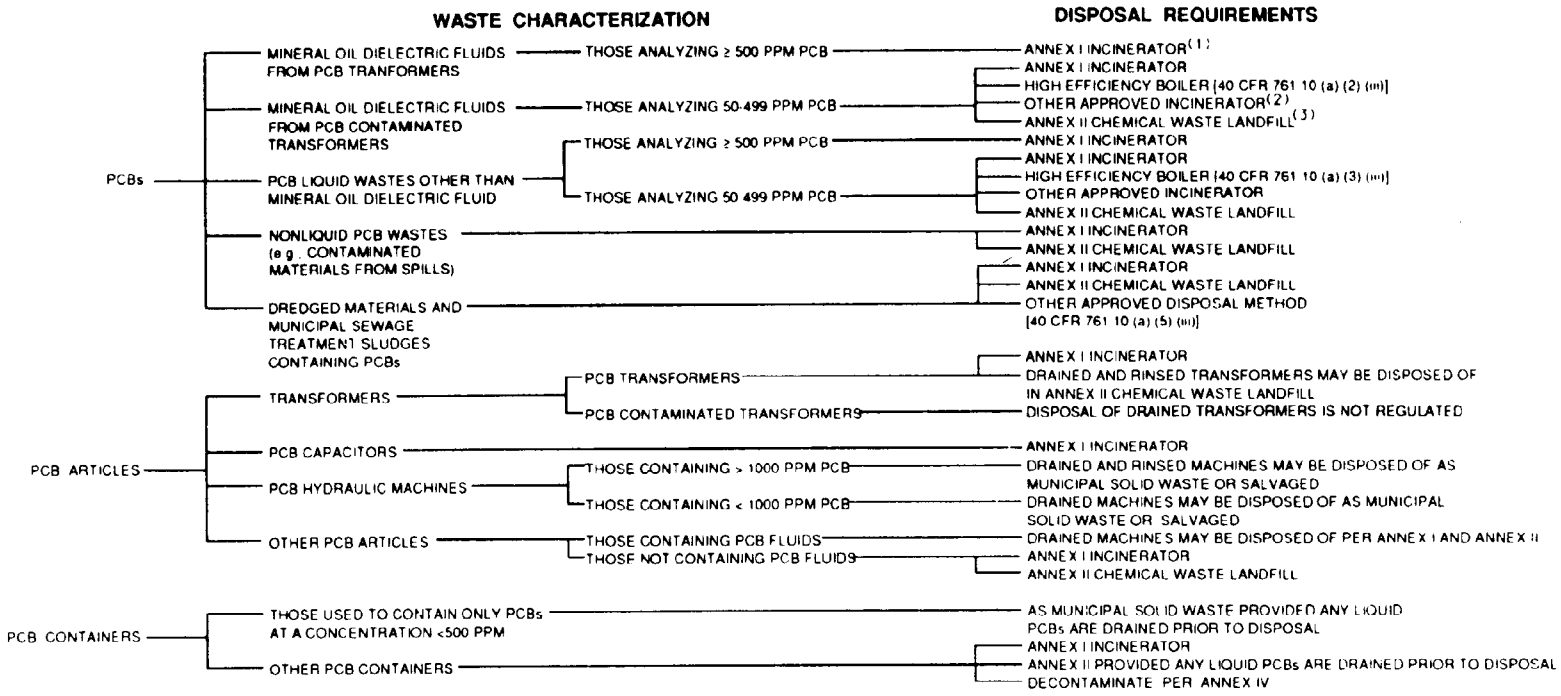
4.4.6.5 *Transporting.* Infectious wastes are to be transported in the original containers, or the sealed bags can be transported in larger carts. Infectious wastes shall be manually transported to avoid rupture of the package. Containers and carts used to transport infectious waste are to be cleaned after each use.

4.4.6.6 *Treatment.* Incineration or steam sterilization are the methods to be used for treating infectious wastes. The ash from incineration or the solid waste after steam sterilization can be disposed of at a sanitary landfill. pathological waste that has been steam sterilized shall be subjected to destruction (grinder) and flushed into the sanitary sewer. Treated liquid wastes shall also be discharged to the sewer system. Care must be taken when flushing waste down the sewer system to ensure that contamination of personnel or the public does not occur.

4.4.6.7 Correct identification and segregation procedures for infectious wastes management are important because the cost of disposal by incineration or sterilization has been estimated at $0.32/lb compared with $0.02/lb for normal landfill disposal. The high cost for permitting, purchasing, installation, and operation of infectious waste incinerators has caused most hospitals to use steam sterilization or private contractors for infectious waste treatment and disposal. Hospital wastes differ from normal municipal refuse in that they can contain as much as 50% disposable plastics. Upon incineration of PVC-containing plastics, HCl gas is produced. Increasing regulatory requirements on HCl and particulate emissions require that most incinerators be equipped with an acid gas scrubber and particulate abatement system. The ash residue from infectious waste incinerators may also require special disposal depending upon the content of leach able heavy metals.

4.4.7 PCB Wastes. Polychlorinated biphenyl wastes are regulated under the Toxic Substance Control Act. Wastes containing or contaminated with PCBs must be disposed of in accordance with 40 CFR 761, Polychlorinated Biphenyls (PCBs) Manufacturing, processing, Distribution in Commerce, and Use prohibition, and any state or local regulations. The PCB disposal requirements specified in Section 761.10 are shown in Figure 4-4A.

4.5 HAZARDOUS WASTES. The Solid Wastes Act was replaced by the Resource Conservation and Recovery Act of 1976. This means that solid wastes and hazardous wastes are both regulated under RCRA. However, hazardous wastes regulations are more stringent and require stricter compliance. Generally



(1) ANNEX I INCINERATOR IS DEFINED AT 40 CFR 761 40.
(2) REQUIREMENTS FOR OTHER APPROVED INCINERATORS ARE DEFINED AT 40 CFR 761 10 (e).
(3) ANNEX II CHEMICAL WASTE LANDFILLS ARE DESCRIBED AT 40 CFR 176 41 ANNEX II DISPOSAL IS PERMITTED IF THE PCB WASTE ANALYZES LESS THAN 500 PPM PCB AND IS NOT IGNITABLE AS PER 40 CFR PART 761 41 (b) (8) (iii)

Figure 4-4A
Disposal Requirements for PCBs and PCB Items

speaking, any solid waste mixed in with hazardous wastes is considered a hazardous waste. Therefore, solid wastes must be kept segregated from hazardous wastes. The following information is based on regulations that are still changing. The expectation is that more stringent requirements will be enforced in the future. The discussion in this section is intended only to make readers aware of the complexities of handling hazardous materials. This document is not meant to be official military guidance in handling such wastes.

4.5.1 Definition of Hazardous Wastes. In accordance with Section 1004(5) of RCRA (PL 94-580), the term "hazardous waste" means a solid waste or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may: (1) cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or (2) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

4.5.2 Hazardous Wastes Identification

4.5.2.1 The criteria for identifying hazardous wastes are as follows:

1. Waste can be analyzed to determine its characteristics using standard test methods, which can be done either in-house or contracted out to certified laboratories.

2. Wastes can be reasonably identified as hazardous by the generator through familiarity with the waste streams.

4.5.2.2 Hazardous Wastes Characteristics. The four common characteristics of hazardous wastes are listed below:

1. Ignitability - wastes that could catch fire during normal handling. Dangers from such fires not only include heat and smoke but also the spread of particles detrimental to health over wide areas.

2. Corrosivity - wastes that attack standard materials, thereby requiring special type of containers. These wastes must be segregated because they could dissolve toxic contaminants from other wastes.

3. Reactivity (explosiveness) - wastes that may react spontaneously and vigorously with water and air during normal handling. These wastes are unstable to shock or heat, and may explode and generate toxic gases.

4. Toxicity - wastes containing toxicants which, if released in sufficient quantities, pose substantial hazard to human health or the environment.

Test procedures to determine the above characteristics are described in 40 CFR 261, Subpart C.

4.5.2.3 *Criteria For Listing Hazardous Wastes.* Per 40 CFR 261.11, Subpart B, the basis for listing solid wastes as hazardous are as follows:

1. wastes exhibiting any of the characteristics identified in 40 CFR 261, Subpart C, shown above

2. wastes found to be fatal to humans in low doses, or capable of causing serious illness

3. wastes containing any of the toxic constituents listed in 40 CFR 261, Appendix VIII, unless the waste is not capable of posing a hazard to human health when. improperly treated, stored, transported or disposed of.

4.5.2.4 An EPA hazardous waste number is assigned for each hazardous waste. Lists of hazardous wastes from specific and nonspecific sources are found in 40 CFR 261.31 and 40 CFR 261.32. Exclusions from these lists are shown in 40 CFR 261, Appendix IX.

4.5.2.5 Discarded commercial products, off-specification species, and container and spill residues containing the generic substances listed in 40 CFR 261.33 are considered hazardous wastes. Any solid waste containing identified hazardous generic substances as an active ingredient of the mixture is a hazardous waste. Additional information regarding the identification of hazardous waste can be obtained from the installation environmental specialist.

4.5.3 Responsibilities

4.5.3.1 In addition to the standards imposed by the initial enactment of RCRA in 1976, the Congress enacted the Hazardous and Solid Waste Amendments of 1984, Public Law 98-616 (November 8, 1984), which substantially strengthened EPA's ability to protect health and the environment.

4.5.3.2 Regulations imposing requirements upon those who generate and transport hazardous waste, as well as those who own or operate a hazardous waste storage, treatment, or disposal facility are found in 40 CFR 260-267. Permit requirements and standards concerning state plan approval are found in 40 CFR 270-271. Each part regulates a different facet of hazardous waste management. Copies of the regulations are available from the U.S. Government Printing Office in Washington, D.C.

4.5.3.3 State hazardous wastes regulations vary nationwide. Some are more stringent than the federal regulations. For example, used oil is classified as hazardous waste in California and other states but not by EPA. Therefore, if an installation located in California plans to burn used oil as fuel in their boilers, a Part B permit may be required. This makes burning of used oil as fuel not economically feasible in California.

4.5.3.4 *DLA Responsibilities.* The Defense Logistics Agency (DLA) is responsible for disposition of all excess and surplus properties (including scrap and hazardous wastes) generated by DoD. The DLA has been charged with the management of hazardous wastes and other waste materials [except those defined in Defense Environmental Quality Program Policy (DEQPP)

Memorandum 80-5 as the responsibility of each branch] including the wastes listed below:

1. Toxicological, biological, radiological, and lethal chemical warfare materials which, by U.S. law, must be destroyed

2. material that cannot be disposed of in its present form because of military regulations, e.g., consecrated religious items and cryptographic equipment

3. municipal-type garbage, trash, and refuse resulting from residential, institutional, commercial, agricultural, and community activities, which the facilities engineer routinely collects

4. contractor-generated materials that are the contractor's responsibility for disposal under terms of the contract

5. sludges resulting from municipal-type wastewater treatment facilities

6. sludges and residues generated as a result of industrial plant process or operations

7. refuse and other discarded materials which result from mining, dredging, construction, and demolition operations

8. unique wastes and residues of a nonrecurring nature which research and development experimental programs generate.

DLA delegated the operational responsibilities to DRMS, DRMR, and DRMO in assisting DoD installations in the disposal of hazardous wastes and other excess or surplus properties.

Once DRMO takes custody of the hazardous wastes, one of their hazardous waste contractors is notified for pickup within 90 days. DRMO's responsibilities are given below:

1. Ensure that all containers are properly packaged, labeled, and manifested.

2. Place appropriate shipping labels and vehicle placards in compliance with DOT regulations.

3. Transport hazardous wastes to an approved Class I landfill for possible treatment and/or disposal.

4.5.3.5 *Installation Responsibilities.* At the installation level, the environmental office is responsible for managing the hazardous waste program. This task involves handling and disposal of hazardous wastes. Basically, the procedures for handling hazardous wastes are as follows:

1. Properly segregate and containerize all hazardous wastes.

2. Label each container and indicate EPA identification number.

3. Prepare disposal turn-in document DD Form 1348-1.

4. Prepare hazardous waste manifest.

4.5.4 Hazardous Waste Management Plan. The Hazardous Waste Management Plan (HWMP) provides guidance to installation personnel in handling and storage of hazardous wastes consistent with regulatory requirements. Guidelines for preparing an HWMP are contained in 40 CFR 260-270. In addition, state and local regulations must also be complied with, if more stringent than the federal requirements.

4.5.4.1 *Scope.* The scope of the HWMP depends on the installation's hazardous waste generation rates. This section is provided only for guidance and is not meant to be a complete discussion of HWMPs. Typically. the HWMP shall contain the following items:

1. Installation Instruction - implements the HWMP within the installation; is signed by the base commander.

2. Regulations - a summary of the applicable federal, state, and local regulatory requirements.

3. Responsibility - duties and responsibilities of all personnel involved with the management of the HWMP are listed.

4. Organizational Chart - an organizational structure showing the HWMP chain-of-command.

5. Hazardous Waste Inventory - a compilation of the quantities of hazardous waste being generated and their sources, type of accumulation, and storage time.

6. Location Map - a base map indicating the boundaries and all areas where hazardous wastes are generated and accumulated.

7. Standard Operating Procedures - detailed explanation of the correct procedures concerning the generation, containerization, collection, labeling, marking, recordkeeping, packaging, handling. storage, treatment, transportation, and disposal of hazardous waste. This is the most critical section in the HWMP.

8. Inspection Plan - a well-organized plan is required to ensure that the hazardous waste management program is implemented correctly and the installation is complying with all pertinent regulations.

9. Training Plan - personnel directly involved in hazardous waste management are required to be trained so they can successfully perform their duties.

10. Spill Contingency Plan - a description of actions installation personnel must take to respond to a spill of hazardous wastes. This

is a requirement for all military installations and will most likely be a separate document. The HWMP shall reference it in this section.

If an installation wants to operate a treatment, storage, and disposal (TSD) facility, the installation must prepare a hazardous waste analysis plan, facility inspection plan, facility contingency plan, facility closure plan, and facility post-closure plan, depending on the facility, pursuant to 40 CFR 264 requirements. These plans must be approved by EPA prior to issuance of TSD permit.

4.5.4.2 *Directives.* DoD directives supporting RCRA regulations are issued to the services for compliance. These directives, such as the Solid and Hazardous Waste Management Collection, Disposal, Resource Recovery, and Recycling Program; DoD Directive 4165.60; Hazardous Waste Minimization Program; Used Solvent Elimination Program; and other related hazardous waste issues are incorporated into the HWMP for compliance by the installations.

4.5.5 Hazardous Waste Handling, Storage, and Disposal

4.5.5.1 Segregation is one of the most important factors required to ensure a successful hazardous waste management program. To minimize contamination, use the original empty product can or container (provided it is in good condition) to collect the hazardous wastes. Containers shall be small enough to easily be handled and filled-up in less than 90 days. This is important if the installation does not have a permitted storage facility.

4.5.5.2 Store flammable hazardous wastes in Department of Transportation (DOT)-approved containers. Ensure these safety cans are properly grounded when used for storage of flammable solvents. In addition, check that containers are fully grounded when transferring flammable hazardous wastes.

4.5.5.3 Hazardous wastes must be packaged correctly so that they can be transported and stored safely pending disposal. Wastes must be packaged in tightly closed containers, either in the original container or in a DOT-approved container. Most wastes should be collected in the original container. The containers must show no signs of deterioration or damage. The container material of construction must be chemically compatible with the contents.

4.5.5.4 *Labeling and Color Coding.* A good segregation program requires proper identification of hazardous waste for both collection and subsequent handling. This is done in the following manner:

- Label containers on the side with the name, MILSPEC and FSN (Federal Stock Number), if available, of the used material to be collected.
- Place a sign (wood or metal) on the designated collection area or hang it over the collected containers.
- Use color coding of drums/containers to identify different types of hazardous wastes for treatment and/or disposal.

4.5.5.5 Manifesting. A generator who transports, or offers for transportation, hazardous waste for offsite treatment must prepare a manifest 0MB control number 2000-0404 on EPA Form 8700-22, and if necessary an EPA Form 8700-22A according to instructions in the Appendix of 40 CFR 62.

The manifest will contain:

1. Generator’s U.S. EPA identification number
2. generator's name, mailing address, and phone number
3. name and U.S. EPA identification number for each transporter
4. designated disposal facility name, site address, and U.S. EPA identification number
5. U.S. DOT description
6. number and type of containers for each waste
7. total quantity of each waste
8. special handling instructions
9. generator's dated signature.

4.5.5.6 *Storage.* Waste generators may accumulate hazardous waste onsite without a permit for 90 days or less after the date of generation. The accumulation date normally starts when a waste is first placed into a container or unused material is declared as waste. An exception to the regulation is allowed if wastes are collected at or near the point of generation. A satellite storage area is the waste collection area at or near the point of generation. The accumulation start date for wastes collected in this manner is the date the container is full or the quantity of hazardous waste exceeds 55 gal or the quantity of acutely toxic waste exceeds 1 qt. Hazardous wastes generated at the shops are collected in appropriately labeled cans or drums adjacent to the work areas. When they become full, they are moved to a central storage area for accumulation of less than 90 days. DRMO takes custody of the hazardous materials and hazardous waste in accordance with DoD 4160.21-M. If the DRMO does not have a permitted facility, the installation retains physical custody of waste while DRMO takes “paper” custody and begins to arrange for disposal.

4.5.5.7 *Disposal.* Hazardous waste and hazardous materials that cannot be treated or recycled onsite are sent to DRMO in accordance with DoD 4160.21-M. Hazardous materials and hazardous waste that cannot be reused or sold by DRMS are disposed of by service contract. DRMS employs contractors to provide a disposal service, which includes transportation and ultimate disposal. It may also include packaging and testing if required. DRMO services through the DRMO contract provide timely removals, discounted prices based on volume, and balanced interest for small generators in remote locations equal to large generators located on main transportation routes. DRMS surveillance of contractor performance reduces the liability for DoD.

4.5.6 Treatment Alternatives. Hazardous wastes generated at the installation's industrial facilities are treated either onsite or offsite. Typical hazardous wastes subjected to treatment are solvents, plating wastes, aircraft paint stripping wastes, and acids. Used petroleum products may or may not be considered hazardous depending on the nature of their contaminants. DoD established the Used Solvent Elimination Program and the Hazardous Waste Minimization Program to provide direction and guidance in reducing hazardous wastes generation.

4.5.7 Petroleum Products

4.5.7.1 Used petroleum products represent another source of revenue for recycling installations provided they are not contaminated. When contaminated, they are somewhat special wastes because in many cases they can be re-used. For example, lube oil which does not quite meet specifications far fighter aircraft might be suitable for maintenance equipment. Re-use is a higher priority than recycling and must be considered before submitting a product for recycling.

4.5.7.2 DoD Directive 4165.60 also addresses the recycling of used petroleum products. AFR 19-14 addresses Air Force policies, duties, accounting guidelines, and documentation instructions for recycling of and/or recovering liquid petroleum products.

1. Installations that generate used lubricating oil and other waste petroleum shall take the following steps:

   a. Maximize the sale through DRMO of recovered used lubricating oil and other waste petroleum for the purpose of re-refining, the most environmentally acceptable recycling option. When allowed by military specifications for lubricating oil products, large installations shall consider negotiating for "closed cycle" re-refining arrangements as a method to further enhance the net value of the used lubricating oil and thereby reduce the cost of replacing the used oil with more expensive virgin lubricating oil products. This does not prohibit justifiable, existing, or proposed "closed cycle" used oil recycling arrangements between a military installation and industry.

   b. Because re-refining may not be economically feasible in some areas of the U.S., used lubricating oil and other waste petroleum may be burned as a fuel or fuel supplement in boilers if no reasonable arrangements can be made for recovery by re-refining. Burning used oil is consistent with the general national conservation principle to conserve our petroleum resources and to preserve the quality of our natural environment. In this regard, the economics of energy recovery alone are not to be considered as sufficient justification for burning waste petroleum products. Environmental effects and conservation also need to be considered as high priority factors in making the final decision.

   c. Report waste inventories as generated and anticipated annual generations, where applicable, to the servicing DRMO for ultimate disposition.

   d. Conduct laboratory analysis, as necessary, to identify abnormal contaminants. If contaminants exceed the used oil specifications, the used oil becomes a hazardous waste and can only be burned in a permitted facility.

e. Segregate, fully identify, label, store, and maintain the integrity of waste petroleum assets pending DRMO disposition.

f. Ensure that waste petroleum suspected of containing 50 ppm or more PCB contamination is identified, segregated, and reported to the servicing DRMO for disposal.

g. Encourage voluntary participation of military and civilian employees who change the crankcase oil in their own personal vehicles to deliver the recovered oil to the DoD collection location as a means of easy disposal, pollution abatement, and effective resource recovery. Cooperative programs with regional and local business, civic, and governmental organizations also might be considered to increase public awareness and improve the economics of recycling.

h. Include military exchanges and other tenant organizations in the installation program for efficiency and economy of centralized recovery efforts.

2. All used oil disposal practices that are not acceptable environmentally shall be discontinued, including use of oil for weed control, insect control, and road dust control; open-pit burning (excluding firefighting training); and dumping into landfills/ sewers/water.

4.5.8 Used Solvent Elimination Program (USE)

4.5.8.1 The USE Program was developed primarily to reduce the costs and future liabilities associated with the disposal of used solvents. The alternatives for reducing solvent generation are

1. onsite recycling
2. offsite recycling
3. burning as fuel.

4.5.8.2 Recycling of solvents is widely practiced within the services installations. Solvent stills are used for recycling organic solvents such as freons, trichloroethane (vapor degreasing solvent), mineral spirits, and paint solvents.

4.5.8.3 Onsite recycling involves the use of a solvent recovery equipment (stills), located at the point of generation. These stills recycle the contaminated solvents through distillation.

4.5.8.4 Offsite recycling means hiring commercial contractors to transport and recycle the solvents outside the military installations.

4.5.8.5 Solvents can be blended with oil as fuel for the boilers. However, precautions must be followed to ensure that halogenated solvents are not mixed with the oil. In addition, the blended fuel oil must be tested for heavy metals contamination (40 CFR 266).

4.5.9 Hazardous Waste Minimization Program. This program was established to provide guidance in reducing hazardous waste generation at all military installations. Each of the services' research laboratories is pursuing research and development work to find a less toxic or biodegradable material as an environmentally acceptable substitute. Likewise, process modification involving the incorporation of any additional equipment or changes in the process itself has been investigated. Examples of process modifications that have been implemented are

1. plastic media blasting
2. zero rinse discharge hard chrome plating
3. can crushing
4. sludge dewatering
5. neutralization.

4.5.9.1 Plastic media blasting is a process for stripping paints from aircraft using plastic media instead of methylene chloride. The plastic media is a less toxic material, and hazardous waste generation has been reduced up to 90% in paint stripping applications.

4.5.9.2 Zero rinse discharge hard chrome plating is a process for recirculating plating rinse water to the plating bath instead of discharging it to the industrial treatment plant. This process modification has reduced plating wastes up to 80%.

4.5.9.3 Can crushing is a mechanical process for compacting empty paint cans and contaminated empty drums. This reduction in volume reduces disposal costs.

4.5.9.4 Dewatering industrial sludges with the use of filter presses squeezes the water out of the sludge, forming a much thicker sludge cake with much less volume.

4.5.9.5 Neutralization is a process for mixing acids with bases in order to decrease the corrosivity of the solution. This treatment is used for battery acids prior to disposal to the industrial wastewater treatment plant.

4.5.10 Household Hazardous Waste

4.5.10.1 Household wastes, including household waste that has been collected, transported, stored, treated, disposed of, recovered (e.g., refuse-derived fuel), or reused is not regulated as hazardous waste. "Household waste" means any material (including garbage, trash, and sanitary wastes in septic tanks) derived from households, residences, hotels, motels, bunkhouses, ranger stations, crew quarters, campgrounds, picnic grounds, and day-use recreation areas. Many household wastes are, however, hazardous in nature and may be ignitable, corrosive, toxic, or reactive. A chemical is also considered hazardous if it may cause a substantial injury, serious illness, or harm to humans, domestic livestock, or wildlife. Tables 4-5A and B list common household and garage chemicals now considered hazardous.

4.5.10.2 Other sources of information about household hazardous wastes include the following.

4.5.10.3 *Labels.* Package warning labels do not always furnish complete and accurate information regarding whether or not a substance is hazardous. However if a package is labeled "CAUTION," "WARNING," "DANGER," or "POISON," assume that the product would be a hazardous waste if regulated.

4.5.10.4 *Hotline.* Even though most installations do not have a specific environmental hotline, information concerning hazardous material can be found at some local activity. The fire department, base security, or the environmental office may offer information regarding a household hazardous waste. Tables 4-SA and B have many practical suggestions. DRMS has a Hazardous Property Hotline to answer hazardous property disposal questions: A/V 932-4133/FTS 522-4133/Commercial (616) 961-4133.

4.5.10.5 *Community Household Hazardous Wastes Program.* Many civilian communities have become aware of the problems of introducing these hazardous wastes to their landfills. As a result, these communities have developed their own household hazardous waste disposal programs. One example is an annual waste collection day. Homeowners bring their chemical wastes to a central location in the city. Then the city/county groups the wastes and disposes of them free of charge to residents. By joining forces with the civilian community, the DoD may be able to save time and money dealing with household hazardous waste.

4.5.10.6 Household Hazardous Waste Handlers' Responsibilities

4.5.10.7 If you have such a program, household hazardous wastes are separated for primarily three reasons. Most importantly, materials that are not compatible must not be stored together to avoid explosions or the emission of toxic fumes. The second reason for segregation is to keep materials to be disposed of at the same location together to avoid resorting the hazardous wastes. Finally, substances that may be recycled, such as oils and paints, shall be combined. It is important not to rely on the warning label to obtain classification information. For example several corrosives are labeled "POISON."

4.5.10.8 *Segregation.* The first rule in segregation is to separate the acidic chemicals from the basic chemicals. Also, the flammable materials shall be separated from the oxidizers. Generally, the poisons containing heavy metals shall be contained separately from the other poisons. The heavy metals contained in poisons include mercury, lead, and arsenic. Before segregating the hazardous wastes, the disposal site management shall be contacted to determine if any segregation requirements are unique to the site.

4.5.10.9 *Limitation.* The quantity of waste that can be transported from any one vehicle per day is limited by the DOT to 5 gal or 50 lb. However, if an individual attempts to turn in more than this amount, it should be accepted to avoid either an accident on the individual's return trip or illegal disposal.

4.5.10.10 *Collection.* Several different schemes for the collection of household hazardous waste have been implemented. These include building-to-building pickup, occasional collection days, and permanent stations. The building-to-building pickup consists of breaking up a

Table 4-5A
Chemical Hazards in the Home

Product	Possible Hazards	Disposal Suggestions	Precautions and Substitutes
Aerosols	When sprayed, contents are broken into particles small enough to be inhaled. Cans may explode or burn.	Put only empty cans in trash. Do not burn. Do not place in trash compactor.	Store in cool place. Propellant may be flammable. Instead: use non-aerosol products.
Batteries: mercury button type	Swallowing one may be fatal if it leaks. Toxicity 5*	Throw in trash.	No substitutes.
Bleach: chlorine	Fumes irritate eyes. Corrosive to eyes & skin. Poisonous if swallowed. Toxicity 3*	Use up according to label instructions.	NEVER MIX WITH AMMONIA! Instead: use non-chlorine bleach or other laundry additive, sunlight, lemon juice.
Detergent cleaners	All are corrosive to some degree. Eye irritant. Toxicity varies. Toxicity 2-4*	Use up according to label instructions or give away. May be diluted & washed down sink.	Instead: use the mildest product suitable for your needs. Liquid dishwashing detergent is mildest, laundry detergent is moderate, automatic dishwasher detergent is harshest.
Disinfectants	Eye & skin irritant. Fumes irritating. Poisonous if swallowed. Toxicity 3-4*	Use up according to label instructions or dilute & pour down sink.	Some may contain bleach, others ammonia -- DO NOT MIX! Instead: use detergent cleaners whenever possible.
Drain cleaners	Very corrosive. May be fatal if swallowed. Contact with eyes can cause blindness.	Use up according to label instructions.	Prevention best; keep sink strainers in good condition. Instead: use plunger, plumber's snake, vinegar & baking soda followed by boiling water.
Flea powders, sprays & shampoos	Moderately to very poisonous. Toxicity 2-4*	Use up or save for hazardous waste collection day.	DO NOT USE DOG PRODUCTS ON CATS. Vacuum house regularly & thoroughly. Launder pet bedding frequently.
Insect and pest sprays	All are poisonous, some extremely so. May cause damage to kidneys, liver, or central nervous system. Toxicity varies from product to product.	Use very carefully & according to label instructions. Save for hazardous waste collection day.	Instead: do not attract insects; keep all food securely covered, practice good sanitation in kitchen & bathrooms, remove trash every night.
Medicines: unneeded or expired	Frequently cause child poisonings.	Flush down sink or toilet.	Check contents of medicine chest regularly. Old medications may lose their effectiveness, but not necessarily their toxicity.
Metal polishes	May be flammable. Mildly to very poisonous. Toxicity 2-4*	Use up according to label instructions or give away.	Use only in well-ventilated area. Instead: substitute vinegar & salt or or use baking soda on damp sponge.
Mothballs	Some are flammable. Eye & skin irritant, poisonous, may cause anemia in some individuals.	Use up according to label instructions or give away.	Do not use in living areas. Air out clothing and other items before use. Clean items before storage. Instead: use cedar shavings or aromatic herbs.
Oven cleaner	Corrosive. Very harmful if swallowed. Irritating vapors. Can cause eye damage. Toxicity 2-4*	Use up according to label instructions or give away. Save for hazardous waste collection day.	Do not use aerosols, which can explode and are difficult to control. Instead: use paste. Or heat oven to 200 degrees, turn off, leave small dish of ammonia in oven overnight, then wipe oven with damp cloth and baking soda. Do not put baking soda on heating elements.
Toilet bowl cleaner	Corrosive. May be fatal if swallowed. Toxicity 3-4*	Use up according to label instructions or wash down sink or toilet.	Ventilate room. Instead: use ordinary cleanser or detergent and baking soda.
Window cleaner	Vapor may be irritating. Slightly poisonous. Toxicity 2*	Use up according to label instruction or give away.	Ventilate room. Instead: spray on vinegar, then wipe dry with newsprint.
Wood cleaners, polishes, and waxes	Fumes irritating to eyes. Product harmful if swallowed. Eye & skin irritant. Petroleum types are flammable.	Use up according to label instruction or save for hazardous waste collection day.	Do not use aerosols. Use only in well-ventilated areas. Instead: use lemon oil or beeswax.

* General Toxicity Ratings

Number Rating	1	2	3	4	5	6
Toxicity Rating	Almost Non-Toxic	Slightly Toxic	Moderately Toxic	Very Toxic	Extremely Toxic	Super Toxic
Lethal Dose for 150 lb. Adult	More than 1 Quart	1 Pint to 1 Quart	1 Ounce to 1 Pint	1 Teaspoon to 1 Ounce	7 Drops to 1 Teaspoon	Less than 7 Drops

Table 4-5B
Chemical Hazards in the Garage and Workshop

Product	Possible Hazards	Disposal Suggestions	Precautions and Substitutes
Aerosols	When sprayed, contents are broken into particles small enough to be inhaled. Cans may explode or burn.	Put only empty cans in trash. Do not burn. Do not place in trash compactor.	Store in cool place. Propellant may be flammable. Instead: use non-aerosol products.
Asphalt roofing compound	Eye irritant. Fumes moderately toxic. Toxicity 3*	Use up according to label instructions or give away.	No substitutes. Do not use indoors.
Auto: antifreeze	Very poisonous. Has sweet taste - attractive to small children & pets. Toxicity 3-4*	Amounts of less than 1 gallon pour down sink with plenty of water. Do not do this if you have a septic tank. Put in a secure container & take to a garage or service station.	No substitutes. Clean up any leaks or spills carefully.
Auto: batteries	Contain strong acid. Very corrosive. Danger to eyes & skin.	Recycle	No substitutes. Trade in old batteries.
Auto: degreasers	Corrosive. Poisonous. Eye & skin irritant. Toxicity 2-4*	Use up according to label instructions.	Choose strong detergent type over solvent type.
Auto: motor oil & transmission fluid	Poisonous. May be contaminated with lead. Skin & eye irritant.	Recycle.	No substitutes.
Auto: waxes & polishes	Fumes irritating to eyes. Harmful if swallowed. Eye & skin irritant.	Use up according to label instructions or give away.	Use outside.
Lacquer & lacquer thinner	Extremely flammable. Very poisonous. Toxicity 4*	Use up according to label instructions or save for hazardous waste collection day.	Ventilate area very well. Do not use in room with pilot light, open flame, electric motors, spark-generating equipment, etc. DO NOT SMOKE WHILE USING.
Paint strippers, thinners, & other solvents	Many are flammable. Eye & skin irritant. Moderately to very poisonous. Toxicity 3-4*	Let settle, pour off cleaner for re-use. Pour sludge into container & seal, or wrap well in newspaper & throw in trash. Use up according to label instructions or save for hazardous waste collection day.	Avoid aerosols. Buy only as much as you need. Ventilate area well. Do not use near open flame. Instead of paint stripper; sand or use heat gun. Use water cleanup products as much as possible.
Paints, oil-based, & varnishes	Flammable. Eye & skin irritant. Use in small, closed area may cause unconsciousness.	Use up according to label instructions or save for hazardous waste collection day.	Ventilate area well. Do not use near open flame. May take weeks for fumes to go away. Instead: use water-based paints if possible.
Pesticides**, herbicides, fungicides, slugbait, rodent poison, wood preservatives	All are dangerous to some degree. Can cause central nervous system damage, kidney & liver damage, birth defects, internal bleeding, eye injury. Some are readily absorbed through the skin. Toxicity 3-6*	Use up carefully, following label instructions. Save for hazardous waste collection day.	Do not buy more than you need. Instead: try hand-picking, mechanical cultivation, natural predators. Practice good sanitation. Choose hardy varieties. Use insect lures & traps. As a last resort, use least toxic suitable pesticides.

**Some pesticides have been banned or restricted. These pesticides shall be carefully stored and saved for a hazardous waste collection day. A partial list of these products follows:
Aldrin, Amitraz, Arsenic Trioxide, Benomyl, BHC, Bithionol, Chloranil, Chlordane, Chlorobenzilate, Copper Arsenate, DBCP, DDD(TDE), DDT, Diallate, Dieldrin, Dimethoate, EDB, Endrin, EPN, Fluorocetamide, Heptachlor, Kepone, Lindane, Mercury, Mirex, OMPA, Parathion, Polychlorinated Biphenyls, Phenarzine Chloride, Pronamide, Safrole, Silvex, Sodium Arsenite, Sodium Cyanide, Sodium Fluoracetate, Strobane, Strychnine, Thallium Sulfate, TOK, Toxaphene, Trifluralin, Vinyl Chloride.

* General Toxicity Ratings

Number Rating	1	2	3	4	5	6
Toxicity Rating	Almost Non-Toxic	Slightly Toxic	Moderately Toxic	Very Toxic	Extremely Toxic	Super Toxic
Lethal Dose for 150 lb. Adult	More than 1 Quart	1 Pint to 1 Quart	1 Ounce to 1 Pint	1 Teaspoon to 1 Ounce	7 Drops to 1 Teaspoon	Less than 7 Drops

collection area into several regions. each region having a different pickup day. The occasional collection day method calls for setting up a collection site only on an occasional basis. However, this method does not offer a permanent solution to the disposal problem. The preferred collection system for household hazardous waste is the implementation of a permanent receiving site, operated on a regular daily basis. This method has been the most successful because it becomes well known by the generators of hazardous waste. A second advantage to the latter alternative is that transportation costs associated with collection are minimized.

4.5.10.11 *Procedures.* The procedure for collecting and handling the incoming hazardous waste consists of four major steps: (1) make sure the container is not leaking and has known contents; (2) identify the hazard category for the waste; (3) document the type, amount, and destination of the waste; and (4) properly pack the waste into a drum of similar materials. The EPA guidelines for packing drums, found in 40 CFR 265.316, are summarized below:

1. The waste must be contained in sealed, sound, and leakproof containers, which will not react with the waste contained.

2. The drum must meet DOT specifications, not have a volume of greater than 110 gal, and must be filled completely with enough absorbent to absorb all the liquid contained in the inner containers.

3. The absorbent material must not react dangerously with, be decomposed by, or be ignited by the waste in the inner containers.

4. All of the wastes contained in the drum must be compatible. Reactive wastes, other than cyanide or sulfide-bearing wastes, must be rendered nonreactive before being packaged in the drum.

4.5.10.12 *Transportation.* Before drums containing the household hazardous waste can be transported, they must be labeled in accordance with the DOT regulations and be recorded on a Uniform Hazardous Waste manifest. All shipments must be made by a licensed hazardous waste hauler, generally obtained through the bidding process, and disposed of in a Class 1 disposal facility.

4.5.11 Education and Training. Handling of hazardous waste requires specialized knowledge and training. This requirement is essential for maintaining both a safe working environment and a work force capable of dealing with emergencies related to hazardous substances. Often the lack of knowledge will lead to a fire, explosion, or spill, and the situation may be worsened by the absence of correct and timely response to the situation. Therefore, proper training can help prevent emergencies and the corresponding losses of property damage and personnel injury.

4.5.12 Regulatory Requirement. Both RCRA and the Superfund Amendments and Reauthorization Act (SARA) call for training in the areas of hazardous waste and materials. RCRA requires installation personnel to be trained in safe techniques of performing their duties and how to respond to emergencies relating to hazardous waste and hazardous materials. Specifically, personnel are to be trained in their installation's hazardous waste management program,

spill prevention control and countermeasure program, and the spill contingency program. The spill contingency program includes instruction on emergency equipment, systems, and procedures.

4.5.13 Training Programs

4.5.13.1 Table 4-5C lists federal regulations and their associated training requirements.

TABLE 4-5C
Federal Regulations Requiring Training

40 CFR 264	Permitted TSDF Standards
40 CFR 265	Interim Status TSDF Standards
40 CFR 151	SPCC Regulations
40 CFR 125	BMP Plan Regulations
29 CFR 1910	OSHA Standards
29 CFR 1915	OSHA Standards
29 CFR 1916	OSHA Standards
29 CFR 1917	OSHA Standards
29 CFR 1918	OSHA Standards
29 CFR 1926	OSHA Standards
29 CFR 1928	OSHA Standards
49 CFR 177	DOT Carrier Regulations

4.5.13.2 Five major regulator programs have specific training requirements. For hazardous waste treatment, storage and disposal facilities (TSDFs) a training program is required under 40 CFR 264.16 and 40 CFR 265.16. For employees of contractors involved in Superfund cleanups, RCRA TSDF operations, spill response teams and first responders, etc., the SARA requires that OSHA develop a set of regulations that includes employee training. These training regulations can be found in 29 CFR 1910.120.

4.5.13.3 OSHA’s Hazard Communication Standard (HCS) requires that a training program be developed for employees exposed to hazardous chemicals. The training requirements can be found in 29 CFR 1910.1200(h).

4.5.13.4 Additional training is required under the Clean Water Act. The Best Management Plan (BMP) requirements under 40 CFR 125 and the Spill Prevention Control and Countermeasure requirements under 40 CFR 151 both have training provisions.

4.5.13.5 Three training programs are specified through SARA. These courses are designed to provide workers with the ability to complete their tasks safely, while minimizing health risks to themselves and to others. The first training program is intended to provide personnel exposed to hazardous substances while working on RCRA and CERCLA initiated projects. This program provides all personnel with 40 h of initial classroom training as well as 3 days of on-the-job training, and 8 h of annual refresher training. All of the trainers must have a higher degree of training than that of what they are to teach. This first training program also requires that supervisors and managers have 8 h of specialized training on managing operations.

4.5.13.6 Workers involved in regular operations at permitted treatment, disposal, storage, and hazardous waste sites are required to participate in the second type of training program. This program consists of 24 h of initial training and 8 h of annual refresher training.

4.5.13.7 Emergency response and HAZMAT teams are to receive training under the third program, which requires regular monthly training totaling 24 h per year. Emergency response teams are made up of police and fire departments. It is the responsibility of the HAZMAT teams to control or stop leaks in containers that contain hazardous substances.

4.5.13.8 Health/safety courses shall also discuss the identification and treatment of Severe allergic reactions and any potential hazards from animals and insects in addition to the risks posed by hazardous materials.

4.5.13.9 Both the Navy and the Marine Corps have their own training requirements. The Marine Corps requires that personnel involved in the handling of hazardous substances and operators of hazardous substance facilities have training according to MCO P11000.8 at Section 4608.9. The Navy requires training be provided for employees involved in hazardous waste operations as stated in OPNAVINST 5090.1, SECTION 11104d.(9). Navy safety and health training requirements are specified by OPNAVINST 5100.23B.

4.5.13.10 *Course Options.* There are five types of training available. These are courses taught by contractors off-base, taught by contractors on-base, taught on-base by installation personnel, prerecorded training courses (video tapes, films, Cassette tape , and self-study courses consisting of booklets and other written materials. For specific information such as availability and nomination procedures of training courses, contact the respective training office.